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Volume 8 September 1983 Number 3

CONTENTS

Biological characteristics of the lindane susceptible and resistant strains of *Tribolium castaneum* Herbst (Coleoptera : Tenebrionidae)—**R. N. Barwal** and **R. L. Kalra** 215

A new species of *Terminalichus* Anwarullah and Khan from South India (Tenuipalpidae : Acari)— **M. Mohanasundaram** 221

New rust mites of Phyllocoptinae (Eriophyidae : Acarina) from South India—**M. Mohanasundaram** 225

Effect of some pesticides on the predatory mite, *Amblyseius tetranychivorus* (Gupta) (Acarina : Phytoseiidae)—**A. Krishnamoorthy** 229

Bio-efficacy of spray application of some newer insecticides against shoot fly *Atherigona* spp. on proso millet (*Panicum miliaceum* L.) in north Bihar—**S. K. Singh, S. S. Yasdani, S. F. Hameed** and **D. N. Mehto** 239

Field evaluation of some soil insecticides in relation to white grub population, germination plant stand and yield of groundnut in U. P., India—**A. S. Srivastava, Y. K. Mathur, A. S. Bhadauria** and **P. M. Nigam** 243

Natural enemy complex of the teak skeletonizer, *Pyrausta machaeralis* Walker (Lepidoptera : Pyralidae) in Karnataka—**B. V. Patil** and **T. S. Thontadarya** 249

Prediction of the Mango hopper, *Idioscopus clypealis* Leth. population in relation to physical environmental factors—**P. L. Tandon, Beche Lal** and **G. S. P. Rao** 263

Record of new eriophyid mites (Eriophyoidea : Acarina) from South India—**M. Mohanasundaram** 269

RNA metabolism in the salivary glands of *Dysdercus koenigii* (Heteroptera, Pyrrhocoridae) : Autoradiographic and electrophoretic investigations—**Dinesh kumar** 269

Histopathological effects of X-irradiation on the ovaries of the red cotton bug *Dysdercus koenigii* Fabr. (Heteroptera : Pyrrhocoridae)—**K. P. Srivastava** and **D. J. Deshpande** 277

A note on the biology of leaf miner *Phytomyza horticola* Goureau on opium poppy—**A. Hussain, Dwijendra Singh, A. K. Tripathi** and **S. M. S. Rao** 287

BRIEF COMMUNICATIONS

Evaluation of some new insecticides against rose aphid, *Macrosiphum rasae* Linn.—**R. P. Shukla** 235

Changes in protein pattern during the moulting cycle and metamorphosis of *Diacrisia obliqua* (Lepidoptera)—**M. Senthamizhselvan** and **J. Muthkrishnan** 293

A tanypodid midge of the genus *Conchapelopia* Fittkau (Diptera : Chironomidae) of India—**P. K. Chaudhuri** and **R. K. Debnath** 297

Hibernation in *Cletus signatus* Walk—**S. C. Dhiman** 301

Euseius vignus a new species (Phytoseiidae : Acari) from Jammu and Kashmir—**N. D. Rishi** and **A. Q. Rather** 303

Chemical control of grapevine stem borer *Celosterna scabrator* Fbr. (Lamiidae : Coleoptera) in Maharashtra—**D. N. Gandhale, B. G. Awate** and **R. N. Pokharkar** 307

Trials with *Paratheresia claripalpis* (Wulp) (Tachinidae : Diptera) an exotic parasitoid against sugarcane borers in the Punjab—**Maninder Sheohmar** and **G. C. Varma** 309

OBITUARY 310

Entomon, 1983, *Vol.* 8, *No.* 3, *pp.* 215 *to* 220

BIOLOGICAL CHARACTERISTICS OF THE LINDANE SUSCEPTIBLE AND RESISTANT STRAINS OF *TRIBOLIUM CASTANEUM* HERBST (COLEOPTERA : TENEBRIONIDAE)

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(Received 2 February 1983)

Lindane resistant and susceptible strains of *Tribolium castaneum* Herbt of different origins were employed to study the biological characteristics such as sex ratio, preoviposition period, fecundity, incubation period and hatchability of the eggs, larval and pupal periods and survival of the adults. *Palampur* strain had its female population higher than other strains. Fecundity of the lindane susceptible and resistant strains, maintained in the laboratory, was higher than the field strains. Survival of larvae of both the susceptible strains was poorer than the resistant strains. In the laboratory selected lindane resistant strain, dry matter content was more and the water content was lesser than the other strains. *Slough* strain, maintained as a standard susceptible strain under laboratory conditions, was found to be less tolerant to starvation as compared to the other strains. It is concluded that superiority of larval survival in the lindane resistant strains over the susceptible strains is associated with the lindane resistance. Differences arising, however, in other biological characteristics of the four lindane susceptible and resistant strains are specific to the strains.

(*Key words*: resistance, strain, insecticide, fecundity, oviposition, larva, pupa)

INTRODUCTION

Biological differences in the insecticide susceptible and resistant strains arise as a result of insecticide stress on the population of an insect species. Such differences can be related to alterations in the reproductive potential, duration and survival of life stages, vigour or other fitness characters confering added advantages to the resistant strain. Such characters provide basis for understanding the dynamics of insecticide resistance in an insect species. Also, the biochemical or physiological phenomena underlying resistance can further be explored.

So far, no consistant pattern in the biological characteristics and their association with the insecticide resistance has emerged in different insect species. In case of *Tribolium castaneum*, BHATIA & PRADHAN (1971) found decreased fecundity of the lindane resistant strain. They observed that the lindane resistant strain did not show any change when reared in the untreated medium. However, there was prolongation in the larval period of the resistant strain when the rearing medium was treated with lindane. But there was significant decrease in the per cent survival of the resistant strain in both the rearing mediums. On the other hand, malathion resistant strain of *T. castaneum* was found biologically superior to the susceptible strain (VERMA & RAM, 1973). Present studies were, therefore, carried out to get comprehensive idea of the biological differences between the lindane susceptible and resistant strains of *T. castaneum*.

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MATERIAL AND METHODS

Insecticide susceptible and resistant strains:

Strains of *Tribolium castaneum* included in those studies, came from different sources. Lindane resistant strain(strain-*R*), was selected in the laboratory from populations collected from different godowns in the Punjab (KALRA *et al.*, 1975). It was highly resistant to lindane. Each generation of this strain was further selected according to ANON (1970) for the maintenance of lindane resistance. Field resistant strain (strain-*L*), was collected from Ludhiana grain market (India). It was found fairly resistant to lindane and was maintained in the laboratory without further exposurue to insecticides. The susceptible strains namely, *Palampur* strain (strain-*P*) and *Slough* strain (strain-*S*) came from Palampur in Himachal Pradesh (India) and Pest Infestation Control Laboratory, Slough, England (U. K.), respectively. Details regarding strains and raising of their cultures have been described by Barwal and KALRA (1982).

TABLE 1. Toxicity of lindane to susceptible and resistant strains of *Tribolium castaneum*.

Strain	LD 50 (μg insect)	Slope ± SE	Resistance Ratio
S	0.069	0.99 ± 0.26	–
P	0.224	1.83 ± 0.32	3.24
L	4.477	0.88 ± 0 18	61.71
R	>12.5	–	>180.64

Sexing of Insects:

Sexing was done at the pupal stage according to GOOD (1936). Last instar larvae of *T. castaneum*, emerging at the surface of wheat flour undergo pupation at the end of the month of starting of the culture. Such larvae were sieved out of the wheat flour and kept for pupation. Sexing of freshly formed pupae was done under compound microscope (magnification, 80 ×) on the basis of morphological differences in the reproductive organs.

Determination of fecundity and life stages:

Males and females of each strain were paired immediately after their emergence as adults from the pupal stage. Each strain was started with 24 pairs of freshly emerged adults in six sets. Each one of the pairs of different strains was confined in a petri dish. Sufficient food was provided to each pair and was replenished every week. Pre-oviposition period of each female beetle was recorded till first egg laying. At each interval of two days, the number of eggs laid were recorded for a period of one month. The eggs laid were separated by sieving the wheat flour, using a sieve of 80 mesh size and were then counted. Incubation period of the eggs laid within 12 hrs of their laying was recorded by keeping 250-500 eggs in petri dishes till hatching at repeated intervals of 12 hrs. Some wheat flour was kept at one corner of the petri dish as a refuge for the larvae emerging out of the eggs. The young ones which hatch out from the eggs at a time were transferred to different petri dishes. They were observed for their larval and pupal survival. Larval and pupal periods were determined from the successful completion of the larval and pupal stages.

Body weight and starvation resistance:

Equal number of one week old male and femle adults were utilised for their fresh body weight. Dry matter content in them was estimated upon oven drying of the adults at 100°C for one hr. Tolerance of adult beetles to starvation was found by keeping a week old 50-60 individuals of each sex without food, under parallel conditions, until their death. Mortality observations were made for seven weeks at an interval of one week. Starvation resistance was expressed on the basis of time required for 50 percent mortality of the adult insects.

RESULTS

Sex ratios of different strains of *Tribolium castaneum* were determined on the basis of 960, 804, 1104 and 607 pupae in the case of strain *S*, *P*, *L* and *R*, respectively. Female to male ratio was found to be 1:0.86 for strain-*S*, 1:1.09 for strain-*L* and 1:1.07 for strain-*R*. In case of strain-*P*, however, most of the larvae developed into female pupae as the female to male ratio emerged out to be 1:0.17 (Table 4).

The number of male and female pairs of the susceptible and resistant strains utilized for the determination of the pre-oviposition period, rate of oviposition, incubation period and hatchability of the eggs were 23, 22, 24 and 23, respectively for strains *S*, *P*, *L* and *R* (Table 2). Pre-oviposition period did not differ significantly. It was found to be 3.87, 4.34, 4.69 and 3.98 days for strain, *S*, *P*, *L* and *R*, respectively. Number of eggs laid by a female in a day were found to be 12.29 for strain-*S*, 10-96 for strain-*P*, 11.95 for strain-*L* and 13.29 for strain-*R*. Strains *S* and *R*, therefore, laid significantly higher number of eggs. Incubation period of all the four strains did not differ significantly from each other and ranged between 2.5—4.0 days. Similarly, there was non-significant difference in the percent successful hatching of the eggs of different susceptible and resistant strains.

Larval period, pupal period and survival of the larvae and pupae of different strains were estimated after raising the young ones hatching out at a time (Table 3). Larval and pupal periods of all the four strains did not differ significantly. Larval period was found to be 14.15, 16.03, 14.28 and 15.10 days and pupal period 5.68, 5.56, 5.25 and 5.29 days for strain *S*, *P*, *L* and *R*, respectively. Survival of the larvae of resistant strains was found to be significantly higher than the larvae of susceptible strains. It was 64.60 and 43.34 percent in case of susceptible strains *S* and *P*, whereas 74.24 and 77.16 per cent in case of resistant strains *L* and *R*, respectively. Survival of the pupae of all the four strains was found to be non-significant.

Differences in the body weight of the adults of susceptible and resistant strains and their tolerance to starvation, estimated on the basis of time taken for 50 percent mortality of the population under starvation, is given in (Table 4). Body weight of susceptible and resistant strains ranged between 1.73 and 1.88 mg.

TABLE 2. Pre-oviposition period, rate of oviposition, incubation period and hatchability of the eggs of susceptible and resistant strains of *Tribolium castaneum*.

Strains	Female	Pre-oviposition period (days)		Number of eggs laid by a female			Incubation period (days)		Hatching (%)
		Average	Range	Per day (Average)	Per month (Average)	Per month (Range)	Average	Range	
S	23	3.87	3.0—5.5	12.29^{ab}	368.61	258—721	3.18	2.5—4.0	97.65 (9.88)
P	22	4.34	3.5—6.0	10.96^{c}	328.86	195—671	3.21	2.5—4.0	96.42 (9.82)
L	24	4.69	3.5—6.5	11.95^{bc}	358.63	225—783	3.21	2.5—4.0	98.00 (9.90)
R	23	3.98	3.5—4.5	13.29^{a}	398.65	315—719	3.26	2.5—4.0	97.06 (9.85)
P = 0.05	—	N S	—	1.12	—	—	N S	—	N S

Figures in parentheses are $\sqrt{X}$ transformation; figures denoted by the same letter are not significantly different; N. S. means non-significant.

TABLE 3. Larval period, pupal period and survival of the larvae and pupae of susceptible and resistant strains of *Tribolium castaneum*.

Strains	Larval period and survival				Pupal period and survival			
	Number of larvae observed	Mean period (days)	Range (days)	Larval survival (%)	Number of pupae observed	Mean period (days)	Range (days)	Pupal survival (%)
S	291	14.15	12—22	64.60 (8.02)[b]	188	5.68	5—7	94.68 (9.73)
P	323	16.03	13—30	43.34 (6.56)[c]	140	5.56	5—7	89.29 (9.45)
L	295	14.28	12—20	74.24 (8.60)[a]	219	5.25	4—6	96.35 (9.82)
R	429	15.10	13—21	77.16 (8.77)[a]	331	5.29	4—7	86.40 (9.30)
P = 0.05	—	N S	—	0.43	—	N S	—	N S

Figures in parentheses are $\sqrt{X}$ transformation; figures denoted by the same latter are not significantly different; N S means non-significant.

Dry matter content expressed as per cent of fresh weight, was found to be 48.18 for strain-*S*, 50.67 for strain-*P*, 48.50 for strain-*L* and 56.65 for strain-*R*. It was found to be significantly higher in the resistant strain-*R*. Tolerance to starvation was found to be 24.27, 29.18, 31.27 and 31.27 days for strain *S*, *P*, *L* and *R*, respectively. So, the susceptible strain-*S* was significantly less tolerant to starvation as compared to the other three strains.

DISCUSSION

Deviations in sex ratio have been encountered in some insect species. Sex ratio was reported to be in favour of females in a *Chicago* strain of *Tribolium castaneum* (SKOLOFF *et al.*, 1960). Female population in the *Palampur* strain was six times higher than the males. This deviation in sex-ratio from the normal value of 1:1 appears to be characteristic feature peculiar to this strain, unlike another susceptible *Slough* strain. Thus, it does not have any relation with the insecticide resistance. Further, such a strain cannot be included in the physiological or biochemical studies on insecticide resistance, as such.

Pre-oviposition period of all the susceptible and resistant strains of *T. castaneum* remained almost the same. Decrease in the pre-oviposition period was, however, reported in the malathion resistant strain of *T. castaneum* (VERMA & RAM, 1973). There was significant difference in the fecundity of lindane resistant and susceptible strains. This difference, however, emerged between the strains maintained in the laboratory for long time and field collected strains. *Slough* and *laboratory resistant* strains were found to be superior to *Field* and *Palampur* strains, which may be the results of inbreeding under close environments. However, decrease in the fecundity was observed in the lindane resistant strain (BHATIA & PRADHAN, 1971) and increase in the malathion resistant strain (VERMA & RAM, 1973) of *T. castaneum*. Also

increase in fecundity has been observed in the lindane resistant strains of *Drosophila melanogaster* (SOLIMAN *et al.*, 1971) and *Phytonomus variabilis* (MARDZHANYAN *et al.*, 1969). Incubation period and hatchability of the eggs of different strains of *T. castaneum* did not differ from each other. Similar results were obtained with malathion resistant strain of *T. castaneum* (Verma & RAM, 1973) and lindane resistant strain of *Blatella germanica* (PERKINS & GRAYSON, 1961). Increase in the hatchability of eggs was, however, observed in the DDT resistant strain of *T. castaneum* (BHATIA & PRADHAN, 1968) and lindane resistant strain of *Musca domestica* (SOLIMAN *et al.*, 1971).

Prolongation in the life cycle is observed in DDT resistant strain of *T. castaneum* (BHATIA & PRADHAN, 1968) and lindane resistant strains of *Dermestes maculatus* (SHAW & LLYOD, 1969) and *B. germanica* (PERKINS & GRAYSON, 1961). VERMA & RAM, however, reported that the malathion resistant strain of *T. castaneum* completed larval development in shorter period. The present investigations did not indicate any difference in the larval period between susceptible and resistant strains of *T. castaneum*. However, survival of the larvae of susceptible strains was poorer than the larvae of lindane resistant strains. Thus, success in the survival of the larvae of lindane resistant strains seems to be associated with the phenomena of lindane resistance. Conversely, decrease in the survival of the larvae of lindane resistant strain of *T. castaneum* was reported by BHATIA & PRADHAN (1971). VERMA & RAM (1973), however, did not find any difference in the survival of malathion susceptible and resistant strains of *T. castaneum*. No difference was found in the pupal period and survival of the pupae of different susceptible and resistant strains in the present investigations. Similar results have been obtained with the malathion resistant strain of *T. castaneum* (VERMA & RAM, 1973).

Body weight, water content and tolerance to starvation were found to differ in the adults susceptible and resistant strains (Table 4). Dry matter content

TABLE 4. Body weight and starvation resistance of the adults of susceptible and resistant strains of *Tribolium castaneum*.

Strain	Sex ratio	Wet weight (mg/adult)	Dry weight (% wet wt)	Water content (% wet st)	Starvation resistance (day)
S	1 : 0.86	1.73 ± 0.01	47.18 (6.85)^{b}	52.22	24.26 (4.92)^{c}
P	1 : 0.17	1.88 ± 0.03	50.67 (7.10)^{b}	49.65	29.18 (5.40)^{b}
L	1 : 1.09	1.77 ± 0.02	48.50 (6.95)^{b}	51.50	31.28 (5.58)^{ab}
R	1 : 1.07	1.78 ± 0.03	56.65 (7.51)^{a}	43.40	31.26 (5.69)^{a}
P = 0.05	—	—	0.37	—	0.24

Figures in parantheses are $\sqrt{X}$ transformation; figures denoted by the same letter are significantly different; N S means non-significant.

of the lindane resistant strain was found to be higher than the other three strains. Increase in dry matter content and subsequent decrease in the water content may be the result of laboratory selection of a population of lindane resistant strain of *T. castaneum*. It, however, cannot be attributed to lindane resistance as the other strain-*L*, having devoloped resistance to lindane under field conditions, did not attain the same characteristic. Adults of *Slough* strain were found comparatively less tolerant to starvation than the adults of all other strains. VERMA & RAM (1973), however, reported that the susceptible strain of *T. castaneum* survived longer than the malathion resistant strain. In general, sensitivity of an adult insect to starvation may be used as one of the criteria of the energy stored during its pre-imaginal life. Such energy differences provide slight tolerance to a strain against some of the insecticides. In the present case, another susceptible *Palampur* strain of *T. castaneum* survived starvation for as long as the lindane resistant strains. Thus, poor survival under starvation may be regarded as the characteristic feature of *Slough* strain and cannot be associated with lindane resistance.

Acknowledgements:—Authors are thankful to Dr. C. E. Dyte, Director, Pest Infestation laboratory, Slough, England (U. K.), for providing the susceptible strain.

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Entomon, 1983, *Vol.* 8. *No.* 3, *pp.* 221 *to* 223

A NEW SPECIES OF *TERMINALICHUS* ANWARULLAH AND KHAN FROM SOUTH INDIA (TENUIPALPIDAE: ACARI)

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(Received 12 June 1982)

A new species of *Terminalichus* Anwarullah and Khan (1973), namely *T. psidi* has been described from South India.

(*Key words: Terminalichus,* Tenuipalpidae from South India)

The genus *Terminalichus* Anwarullah and Khan (1973) was erected to hold *T. Karachiensis.* Later Maninder and Ghai (1978) recorded this species along with two other new species from Northern India. The present paper gives the description of *T. psidi* sp. nov. which is the fourth species under the genus and the first record of this genus from Southern India.

Terminalichus psidi, sp. nov. (Figs. 1 to 5)

Female: Body elliptical, deep yellowish; 230 [1] long including rostrum, 110 wide; gnathosoma 45 long with a pair of simple setae ventrally; rostrum just reaching the distal end of the femur I; palpus 3 segmented; basal segment about 2 long; second segment 10 long with a seta at its distal end about 13 long; terminal segment 2 long with terminal seta about 6 long. Rostral shield bifurcate, reaching at about the middle of femur I acute at its anterior end; propodosoma smooth; with three pairs of dorsal setae; DPI, 35 long; DP II, 85 long, DP III, 35 long, situated just below the eyes. Hysterosoma smooth, a pair of humerals 30 long; four pairs of dorso-laterals, DLH I, 60 long; DLH II, 60 long; DLH III, 12 long and DLH IV, 17 long. All setae on dorsum slender and serrate.

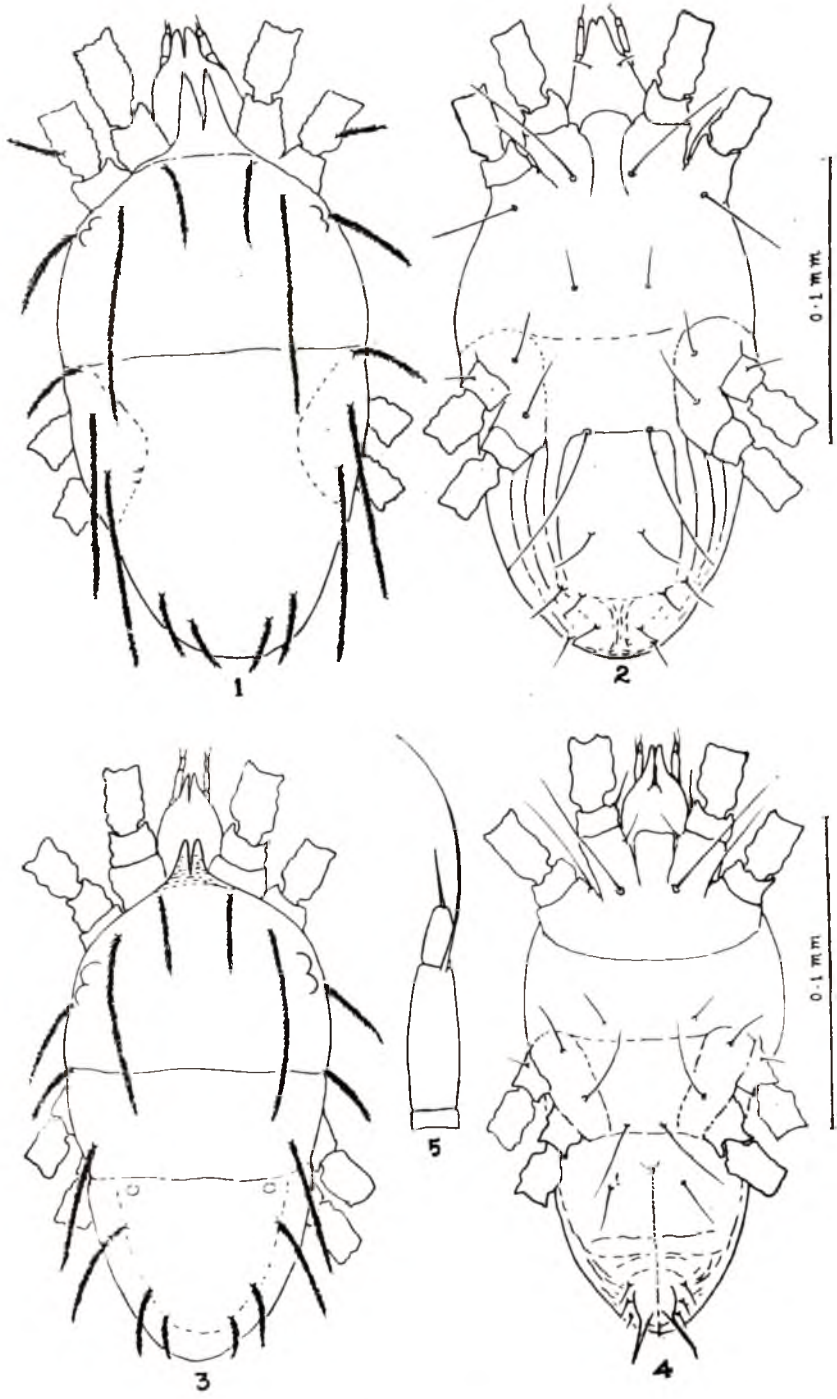
Venter with a pair of medioventral propodosomals IC I, 45 long; a pair of anterior medioventral metapodosomals, 8 long, a pair of posterior medioventral metapodosomals, 40 long; one pair of pregential setae 10 long; two pairs of genital, and two pairs of anal setae. All setae on venter simple, the smooth ventrogenital plate extending to the posteior margin of coxae IV; with 4 longitudinal thickenings or folds on either side of the ventrogenital plate.

Leg segments wrinkled, setae on legs I to IV: Coxae 2,2,1,1; trochanters, 1,1,1,0; femora, 2,2,1,1: genua, 1,1,0,0; tibiae, 2,2,1,1; tarsi 6 (1), 6 (1), 4,4.

Male: Very common, 195 long including rostrum, 90 wide. Setation similar to female, hysterosoma divided by a suture into a metapodosoma and an opisthosoma. Male rostral shield short and blunt.

Types: A **holotype** slide and 6 **paratype** slide with ♂♂ and ♀♀ INDIA: TAMILNADU, Villupuram, ex. *Psidium gujava* (Myrtaceae) guava, collected on

[1] All measurements are in μm, unless othewise stated.



Figures 1—5. *Terminalichus psidi*, sp. nov. 1. Dorsal view of female; 2. Ventral view of female; 3. Dorsal view of male; 4. Ventral view of male; 5. Palpus.

9.iii.1982, M. Mohanasundaram (No. 87) (TNAU).

The mites are under surface leaf vagrants causing negligible symptoms.

Remarks: This species comes close to *Terminalichus karachiensis* Anwarullah and Khan (1973) but could be differentiated from it by the second dorsal propodosomal setae longer than the prodosoma and reaching beyond the base of the second dorsolateral setae.

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Entomon, 1983, *Vol.* **8**, *No.* 3, *pp.* 225 *to* 227

NEW RUST MITES OF PHYLLOCOPTINAE (ERIOPHYIDAE: ACARINA) FROM SOUTH INDIA

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(Received 26 June 1982)

The paper presents the descriptions of two new Phyllocoptine mites collected from South India. They are *Phyllocoptes acaciae* sp. nov; and *Epitrimerus parasakthi* sp. nov.

(Key words: new Phyllocoptine mites, Eriophyidae, South India)

In the course of survey of phytophagous mites, two new rust mites belonging to Phyllocoptinae were collected and studied. They are *Phyllocoptes acaciae*, sp. nov: and *Epitrimerus parasakthi* sp. nov. The mites have been adequately sketched. The type- and paratype- slides have been deposited at the Department of Agricultural Entomology collections, Tamilnadu Agricultural University, Coimbatore, India (TNAU).

1. Phyllocoptes acaciae, sp. nov. (Figs. 1–8)

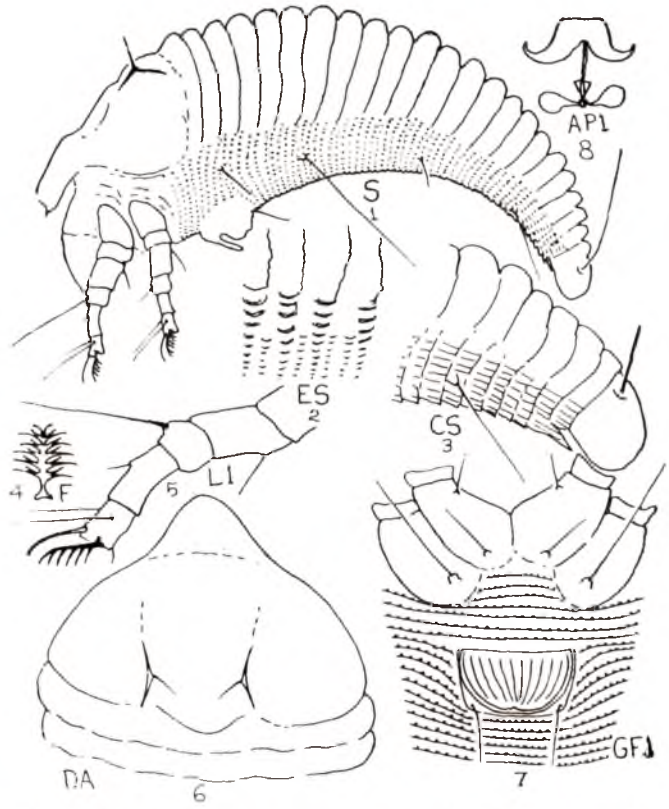
Female: White, worm like, 165—170[1] long, 55 thick, rostrum 20 long, down curved, antapical seta 5 long. Shield 50 wide, 43 long, shield area and sides of shield clear, anterior shield lobe overhanging rostrum base, ending in a sharp point. Dorsal tubercles away from rear shield margin, 13 apart, dorsal setae 7 long, pointing upwards. Foreleg 30 long; tibia 6 long, tibial setae minute, less than 1 long; tarsus 5 long; claw 8 long, curved, feather claw 6 rayed; hindleg 26 long, tibia 5 long, claw 8 long, curved. Foreleg with all usual setation: hindleg with all setation but the hind patellar seta minute, coxae broadly joined, with all three setiferous tubercles, coxal area smooth. Abdomen with about 23 smooth, broad tergites and about 56 microtuberculate sternites: lateral seta 7 long on ring 8; first ventral seta 50 long on ring 20; second ventral seta 6 long on ring 35; third ventral seta 16 long on ring 5 from behind; caudal seta 60 long; accessory seta absent. Female genitalia 23 wide, 15 long; coverflap with about 10 lines; genital seta 26 long.

Male: Not known.

Types: A **holotype** slide and 5 **paratype** slides, all with females. INDIA, KARNATAKA, Mysore, Chamundi Hills, 12.v.1982, ex. *Acacia arabica* Linn. (Fabacae) Coll. M. Mohanasundaran (No. 466). Mites vagrant on the leaflets.

Remarks: This species resembles *Phyllocoptes indicae* Keifer (1975) in the shape of the downturned anterior shield lobe, clear coxal area, position of the first setiferous coxal tubercles and the lines on the genital coverflap; but could be separated from it by the clear shield area; non tuberculate tergites, six rayed featherclaw apart from the measurements.

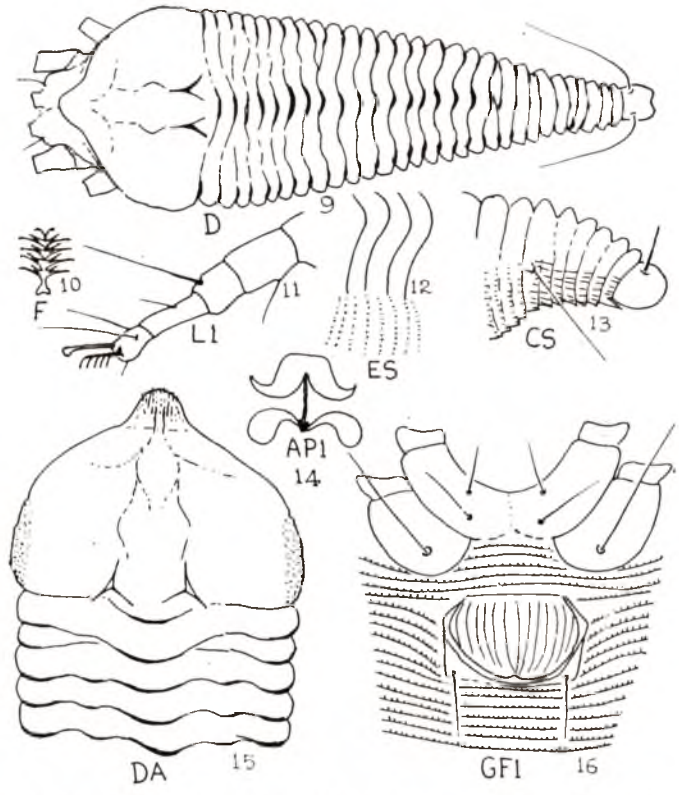
[1] All measurements are in μm, unless otherwise stated.



Figs. 1—8. *Phyllocoptes acaciae*, sp. nov. 1. Side view of mite, 2. Side skin structure; 3. Side view of caudal end; 4. Feather claw; 5. left foreleg; 6. Dorsal view of anterior end; 7. Female genitalia and coxae from below; 8. Female internal apodeme.

2. Epitrimerus parasakthi, sp. nov. (Figs. 9—16).

Female: White, dorsoventrally flattened. 165—170 long, 58 wide, wedge shaped, rostrum 18 long, down curved, antapical seta 5 long; shield 55 long, 42 wide, shield area clear except for two wavy depressions representing admedians; sides of shield coarsely granular, anterior shield lobe granular, overhanging rostrum base; dorsal tubercles at rear shield margin, 15 apart; dorsal seta 5 long pointing upwads and backwards. Foreleg 28 long, tibia 7 long; tibial seta 3 long; tarsus 5 long, claw 5 long; knobbed at tip; featherclaw 5 rayed. Hindleg 25 long, tibia 6 long, claw 5 long, hind femoral seta short, coxae broadly joined without a sternal ridge; all three setiferous tubercles present; coxal area clear. Abdomen with about 28 broad smooth tergites and 72 microtuberculate sternites. Abdominal dorsum with a median ridge and two lateral ridges with shallow troughs on either side of middle ridge and with a faint ridge for short distance in the troughs on either side. Lateral seta 20 long on ring 12; first ventral seta 42 long on ring 26; second ventral seta 6 long on ring 45; third ventral seta 23



Figs. 9—16. *Epitrimerus paraskthi*, sp. nov. 9. Dorsal view of mite; 10. Feather claw; 11. Left foreleg; 12. Side skin structure; 13. Side view of caudal end; 14. Female internal apodeme; 15. Dorsal view of anterior end; 16. Female genitalia and coxae from below.

long on ring 6 from behind; caudal seta 34 long; accessory seta not visible. Female genitalia 19 wide, 15 long; cover-flap with 12—14 lines; genital seta 7 long.

Male: 160 long, 55 wide, genitalia 15 wide, genital seta 6 long.

Types: A **holotype** slide and 5 **paratype** slides with females and males, INDIA: TAMILNADU. Pennadam, 18.v.1982 ex. *Ficus* sp. (Moraceae) Coll. M. Mohanasundaram (No. 469).

Remarks: The flat mites usually adhere to the lower side of the leaf laminae with restricted movement. This species resembles *Epitrimerus trilobus* (Nalepa) (Keifer, 1942) in its shield pattern and granular sides of shield, but could be differentiated from it by the five rayed feather claw, and the measurements. Since the mite was collected near a Parasakthi temple, it is named after it.

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EFFECT OF SOME PESTICIDES ON THE PREDATORY MITE, *AMBLYSEIUS TETRANYCHIVORUS* (GUPTA) (ACARINA: PHYTOSEIIDAE)

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The susceptibility of the phytoseiid mite, *Amblyseius tetranychivorus* (Gupta), a native predator of spider mites of vegetable crops, to fourteen pesticides, which are commonly recommended for pests and diseases of horticultural crops, was studied under laboratory conditions to select less toxic chemicals which in turn can effectively be used in integrated control programme. Adult gravid females were exposed to recommended concentration of chemicals sprayed on a glass substrate and shade dried. The study showed that the adults were little affected by fungicides like wettable sulphur and dithane at 2 g/lit each on the day of spraying. The residues of these chemicals were found to be totally innocuous. Among insecticides and acaricides tested, endosulfan at 0.07% though highly toxic on the day of spraying, subsequently its residue produced little to no mortality to the predatory mite. The other chemicals like dicofol, monocrotophos, fenitrothion, chlorpyriphos, quinalphos, dimethoate, methyl demeton, phosalone and methomyl (all at 0.05%) malathion and carbaryl (at 0.1%) were very highly toxic to the predatory mite, inflicting 100% mortality within 24 hour after spraying. The residues of these chemicals were also highly toxic even 9 days post treatment.

(Key words: Phytoseiid mite, *Amblyseius tetranychivorus,* susceptibility to pesticides)

INTRODUCTION

Pesticidal applications often are directed against phytophagous insects and mites regardless of the extent of the populations. This is not more uncommon in vegetable crops where emphasis is given to produce good marketable product. In such situations, the secondary pests like spidermite often reach economically damaging proportions when repeated pesticide applications eliminate natural enemies. The phytoseiid mites, the principal natural enemy of the spider mites, are generally known to be very much susceptible unlike the spider mites to many pesticides (RISTICH, 1956; WATVE & LIENK, 1975, 1976; ROUSH *et al.* 1980). But ROCK & YEARGAN (1971) have reported that there are several selective chemicals which are more toxic to insects and spider mites than to phytoseiid mites. Safe pesticide management is an essential component and possibly a pre-requisite of integrated pest management. Therefore a study was conducted to understand the effect of contact toxicity of many pesticides, commonly used in horticultural crops, to the phytoseiid mite before drawing up any integrated control programme.

Amblyseius tetranychivorus (Gupta), an important native predatory mite of spider mites of vegetable crops (PUTTASWAMY &

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CHANNA BASAVANNA, 1979; GUPTA, 1978) was used to test against pesticides and the results are presented in this paper.

MATERIALS AND METHODS

The predatory mite *A. tetranychivorus* was mass reared in the laboratory on castor pollen grains, a method described by KRISHNAMOORTY, (1982). Laboratory studies on the susceptibility of phytoseiids to pesticides as often dealt with adult females, though the technique applied vary a good deal (CROFT & JEPPSON, 1970; CROFT & NELSON, 1972; CROFT & STEWART, 1973), in the present study one to two day old gravid females were tested. A total of 14 pesticides were tested at concentration recommended and the chemical name, common name, formulation and dosage to which the mites were exposed are furnished in Table 1. Desired concentrations of the pesticides were obtained by diluting them in water.

Many small rearing units were prepared with petriplates of 15 and 9 cm. The small inner inverted petriplate which formed as a substrate was sprayed with pesticide solution using a glass atomizer. Care was taken to maintain uniform size of droplet in all treatments. The petriplate was then held in shade for 30 min for drying. A strip of cotton wool was kept around the inner plate in order to prevent the mite escape. Water was maintained in the outer petriplate. The inner diameter of the inner plate was maintained to 6 cm by adjusting the strip of wet cotton wool. Sufficient quantity of pollen grains were dusted to each unit before releasing predatory mites. An untreated check was also maintained to correct the mortality in the pesticidal treatments. Each treatment was replicated three times with 10 individuals per replicate. All units were held in dark chamber until observation was over. The predatory mite was continuously exposed for 48 hr period and observation was made at 24th and 48th hr to record adult mortality due to pesticides. Moribund and tottering mites also were considered as dead per cent mortality was computed accordingly.

For testing the effect of pesticide residues, persisting on treated surface, the gravid females were exposed to the treated surface on third, fifth, seventh, and ninth day post treatment. Observation was made at 24th and 48th hr following releases of adults. If mortality was observed to be 100 per cent at 24 hr, the same percentage mortality was used at 48 hr. Zero values in the mortality were converted into 0.01 and the data were transformed into corresponding angles (Arc. sine $\sqrt{\text{percentage}}$) for statistical analysis. 'F' test was used to analyse the differences in the mortality of the predator due to different pesticidal treatments. All studies were conducted at room temperature of $28 \pm 2^{\circ}C$.

RESULTS

The data on the contact toxicity of fourteen pesticides to the gravid females of *A. tetranychivorus* are presented in Table 2. Among the pesticides tested sulphur and dithane each at 2 g/lit are found to be significantly less toxic and produced 16.66 and 13.33 per cent adult mortality respectively during 48 hr continuous exposure after spraying. Whereas the toxic levels of other chemicals such as endosulfan (0.07%), dicofol, monocrotophos, fenitrothion, chlorpyriphos, quinalphos, dimethoate, methyldemeton, phosalone, methomyl (all at 0.05%) malathion and carbaryl (at 0.1%) are all on par with each other and have inflicted 100 per cent mortality of the gravid females during 48 hr continuous exposure (Table 2).

The per cent mortality of adult gravid females of *A. tetranychivorus* obtained due to persistence of pesticide residues is also indicated in Table 2. The residues of sulphur and dithane are found to be totally innocuous throughout the study period. Whereas the residue of endosulfan is found to be significantly less toxic causing 10 per cent mortality to the gravid females, when the mites were exposed continuously for 48 hr to the treated suface on 3rd day post treatment. Subsequently no mortality was recorded

TABLE 1. List of pesticides screened against adult females of predatory mite, *A. tetranchivorus*.

	Chemical name	Common name/ trade name	Formulation	Dose
1.	Endosulfan	Thiodon	35 EC	2.00 ml/lit
2.	Dicofol	Kelthane	18.5 EC	2.75 ,,
3.	Monocrotophos	Nuvocron	40 EC	1.25 ,,
4.	Fenitrothion	Folithion	50 EC	1.00 ,,
5.	Chlorpyriphos	Dursban	20 EC	2.50 ,,
6.	Quinalphos	Ekalux	25 EC	2.00 ,,
7.	Dimethoate	Rogar	30 EC	1.67 ,,
8.	Malathion	Cythion	50 EC	2.00 ,,
9.	Methyl demeton	Metasystox	50 EC	1.00 ,,
10.	Phosalone	Zolone	35 EC	1.43 ,,
11.	Methomyl	Lanate	20 EC	2.50 ,,
12.	Carbaryl	Banguvin	50 WP	2.00 g/lit
13.	Sulphur	Sulfovit	80 WP	2.00 g/lit
14,	Dithane	Dithane Z-78	78 WP	2.00 g/lit

when the adults were exposed on fifth, seventh and ninth day post treatment.

Hundred per cent adult mortality is recorded in residue of dicofol upto 5th day post treatment and thereafter there is significant reduction in mortality during 24 hr exposure period both on seventh and ninth day post treatment (Table 2). But at 48th hr the adult mortality significantly rose to 86.6 and 73.8 per cent on seventh and ninth day post treatment respectively and recording high toxic nature of dicofol residue to the predatory mite. The residues of malathion and chlorpyriphos on 7th and 9th day post treatment have though effected 76.66 and 80.00 per cent mortality during 24 hr exposure period, the surviving adults have also been observed dead resulting 100 per cent mortality in each residue during 48 hr. All other residues of remaining chemicals have inflicted 100 per cent adult mortality during 24 hr exposure period itself even on 9th day post treatment.

Statistical analysis for 5th day post treatment was not done as the mortality difference between treatment 1, 13, 14 and remaining pesticides was significantly high (Table 2.).

Based on the results thus obtained the degree of contact toxicity of pesticides to the adult females of *A. tetranychivorus* is arranged in ascending order:
(i) On the day of spraying: Dithane < sulphur < endosulfan = dicofol = monocrotophos = fenitrothion = chlorpyriphos = quinalphos = dimethoate = malathion = methyl demeton = phosalone = methomyl = carbaryl. (ii) for persisting pesticide residue Dithane = sulphur endosulfan < dicofol < malathion < chlorpyriphos < monocrotophos = fenitrothion = quinalphos

TABLE 2. Effect of pesticides on adult females of *A. tetranychivorus*.

Tr. No.	Pesticides	% mortality during exposure period of		% Mortality due to residues							
				3rd day p. t.		5th day p. t.		7th day p. t.		9th day p. t.	
		24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr
1.	Endosulfan	93.3 (87.22)	100 (90.0)	0 (0.57)	10 (15.53)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
2.	Dicofol	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	70 (57.57)	86.6 (78.56)	56.6 (49.42)	73.3 (59.58)
3.	Monocrotophos	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
4.	Fenitrothion	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
5.	Chlorpyriphos	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	80 (69.07)	100 (90.0)	53.3 (47.91)	100 (90.0)
6.	Quinalphos	100 (90.0)	100 (90.0)	100 (90.00)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90,0)
7.	Dimethoate	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
8.	Malathion	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	76.66 (61.79)	100 (90.0)	66.6 (55.65)	100 (90.0)
9.	Methyl demeton	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
10.	Phosalone	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
11.	Methomyl	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
12.	Carbaryl	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
13.	Surphur	10 (15.54)	16.66 (24.36)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
14.	Dithane	6.6 (12.86)	13.33 (21.68)	0 (0.57)	0 (0.57)	0 (0.67)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
C D (P = 0.05	Between treatment	4.07		2.97		—		4.56		2.98	
,,	Between period	1.54		1.12		—		1.72		1.13	
,,	Interaction bet. treatment and period	5.75		4.20		—		6.45		4.21	

p. t. = post treatment

= dimethoate = methyl demeton = phosalone = methomyl = carbaryl.

DISCUSSION

Sulphur, mainly used as fungicide and acaricide and dithane, a fungicide are found to be least toxic to the adult gravid females of *A. tetranychivorus* in this present study. Similar observation was also made by KASHIO & TANAKA (1981) and OVERNEER & VANZON (1981) with sulphur (wettable sulphur) and Zineb (Dithane Z-78) on related species *A. deleoni* Muma & Denmark and *Typholodronus pyri* Scheuten *A. potentiallae* Garman and *A. bibens* Blommers respectively. The chemical endosulfan was found to be highly toxic to the adults of *A. tetranychivorus* on the day of spraying but subsequently the residue was found to be little to non-toxic. Although there is a report of toxic nature of endosulfan to the predators like *T. pyri*, *A. potentiallae* and *A. bibens* (OVERNEER & VANZON, 1981) ,the same chemical was found to be non toxic or less toxic to the adults of *A. fallacis* (Garman) (WATVE & LIENK, 1975 and HISLOP & PROKOPY, 1981). This sort of different result was quite possible as the level of tolerance is varied with species.

The other chemicals such as dicofol, monocrotophos, fenitrothin, chlorpyriphos, quinalphos, dimethoate, malathion, methyl demeton, phosalone, methomyl and carbaryl were found to be highly toxic on the day of spraying. Their residues were also highly toxic to the adults of *A. tetranychivorus*. The high toxic nature of some of these chemicals reported in this paper is in agreement with that of earlier workers like HERNE & CHANT (1965) for dicofol with the predatory mite *Phytoseiulus persimilis* Athias—Henriot; LO *et al.* (1979) for monocrotophos with *A. taiwanicus* Ehara, WATVE & LIENK, 1975, 1976; ROUSH *et al.* (1980), CROFT & NELSON (1972), CROFT & STEWART (1973) for dimethoate, phosalone and carbaryl with *A. fallacis*, *T. occidentalis* NESBITT & RISTICH (1956) for malathion with *T. fallacis* (*A. fallacis*) and PEACOCK *et al.* (1978) for methomyl with *T. occidentalis*.

WYMAN *et al.* (1978) are of opinion that biological control of insect pests generally does not achieve the required levels of control for vegetable crops when used alone, but it forms an important part of integrated control programme. The results of the present study indicated that only the pesticides like sulphur, dithane and certain extent endosulfan can be used safely against the predatory mite *A. tetranychivorus* in an integrated control programe, since the residues of other chemicals are highly toxic even ninth day post treatment. Any amount of predatory mite population build up even twelve to fifteen days after spraying, successive sprays will eliminate the predator and in the absence of such important natural enemy, insecticide resistant population of spidermites will attain a status of major pest.

Therefore unless and otherwise the insect and mite pest populations really warrant insect such pesticidal spray, one should not by sheer presence of fewer number of insects or mites pest, apply pesticides.

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BRIEF COMMUNICATION

EVALUATION OF SOME NEW INSECTICIDES AGAINST ROSE APHID, *MACROSIPHUM ROSAE* LINN.

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(Received 31 December 1982)

Thirteen insecticides belonging to synthetic pyrethroids, organophosphate and carbamate groups were evaluated for their bio-efficacy against rose aphid, *Macrosiphum rosae* Linn. Monocrotophos (0.05%) was most effective upto 15 days after spray followed by chlorpyriphos, dimethoate and methomyl. Synthetic pyrethroids were moderately toxic whereas malathion was least effective. Study suggests the alternate spraying with 0.05% monocrotophos and chlorpyriphos at fortnightly intervals during new growth period for its effective control.

(Key words: bio-efficacy, synthetic pyrethroid, organophosphate, carbamate, rose aphid, *Macrosiphum rosae* Linn.)

Rose plants are attacked by several insect pests, among which rose aphid, *Marcosiphum rosae* Linn. is very serious. The nymphs and adults suck the sap of tender shoots, leaves, flower buds and flowers resulting in loss of plant vitality and hence flower production. In the past, few chemicals have been screened against this pest among them dimethoate, malathion, parathion and resmethrin have been found initially effective upto 3 days after spray (KLICZA & PALOSZ, 1969; KLICZA & SAMOL, 1969; RALPH *et al.*, 1974; BALASUBRAMANIAM, 1974) but the workers did not see any persistance beyond 3 days. Present investigation was, therefore, aimed to screen thirteen insecticides belonging to different groups like newly evolved chemicals-synthetic pyrethorid, organophosphate, carbamate and their persistance.

Studies were conducted at Indian Institute of Horticultural Research, Experimental farm, Hessaraghatta, Bangalore during January to February, 1981 on bio-efficacy of 13 insecticides viz., fenvalerate (Fenval, 20 EC), permethrin (Permasect, 20 EC), cypermethrin (Ripcord, 10 EC), deltamethrin (Decis, 2.8 EC) methyl parathion (Metacid, 50 EC), methomyl (Lannate, 20 EC), monocrotopohs (Nuvacron, 40 EC), chlorpyriphos (Dursban, 20 EC), dimethoate (Rogor, 30 EC), phosphamidon (Dimecron, 100 EC), carbaryl (Sevin, 50 WDP), malathion (50 EC) and endosulfan (Endosul, 35 EC) replicated thrice in randomized block design including water sprayed plants as control. A pre-treatment aphid count was taken from tagged plants by selecting three tender shoots of 7.5 cm length from each plant just before spraying. Insecticidal spray was given with high volume sprayer upto full coverage of plants. Post-treatment aphid counts were taken at 1, 3, 9 and 15 days intervals. Data were subjected to 'log X + 2' transformation before analysis of variance.

TABLE 1. Bio-efficacy of some new insecticides against rose aphid, *Macrosiphum rosae* Linn.

Treatments/Conc (%)	Pre-treatment count	Post treatment count (days)			
		1 day	3 days	9 days	15 days
1. Malathion (0.05)	176.67 (11.68)^{bc}	0.0 (1.60)^{a}	3.33 (2.97)^{a}	118.33 (10.99)^{cd}	225.67 (12.32)^{e}
2. Endosulfan (0.07)	90.00 (9.60)^{bc}	0.0 (1.60)^{a}	0.0 (1.60)^{a}	10.00 (3.72)^{ab}	37.33 (8.06)^{ab}
3. Carbaryl (0.2)	83.33 (10.22)^{bc}	0.0 (1.60)^{a}	0.0 (1.60)^{a}	25.00 (7.34)^{bc}	81.67 (10.16)^{b}
4. Phosphamidon (0.05)	68.33 (9.67)^{bc}	0.0 (1.60)^{a}	0.0 (1.60)^{a}	18.00 (5.98)^{b}	56.67 (9.27)^{ab}
5. Dimethoate (0.05)	128.33 (10.40)^{bc}	0.0 (1.60)^{a}	0.0 (1.60)^{a}	7.67 (5.45)^{b}	34.67 (6.75)^{a}
6. Fenvalerate (0.02)	123.33 (10.58)^{bc}	4.0 (3.90)^{b}	5.0 (3.24)^{a}	25.0 (7.52)^{bc}	50.00 (8.61)^{ab}
7. Permethrin (0.02)	115.00 (10.67)^{bc}	25.0 (7.42)^{c}	38.33 (8.43)^{b}	23.0 (7.27)^{bc}	53.33 (9.11)^{ab}
8. Cypermethrin (0.02)	55.67 (9.32)^{ab}	16.0 (6.58)^{c}	20.67 (7.13)^{b}	27.67 (6.80)^{bc}	68.33 (9.67)^{ab}
9. Deltamethrin (0.02)	46 67 (8.86)^{ab}	18.0 (6.87)^{c}	55.00 (9.27)^{c}	60.0 (9.43)^{cd}	65.33 (9.67)^{ab}
10. Methyl parathion (0.03)	38.33 (8.47)^{b}	0.0 (1.60)^{a}	0.0 (1.60)^{a}	7.33 (5.77)^{b}	36.57 (8.28)^{ab}
11. Metomyl (0.05)	25.00 (7.56)^{ab}	2.33(3.14)^{b}	0.0 (1.60)^{a}	17.67 (6.29)^{b}	29.33 (7.78)^{a}
12. Chlorpyriphos (0.05)	35.00 (7.83)^{ab}	4.0 (3.50)^{b}	0.0 (1.60)^{a}	3.33 (3.50)^{ab}	13.00 (6.12)^{a}
13. Monocrotophos (0.05)	146.67 (11.50)^{bc}	0.0 (1.60)^{a}	0.0 (1.60)^{a}	0.67 (2.13)^{a}	10.67 (5.79)^{a}
14. Control	154.33 (11.57)^{bc}	200.0 (12.18)^{d}	183.33 (12.0)^{d}	196.67 (12.16)^{d}	163.33 (11.69)^{c}
CD 5%	(2.226)	(1.412)	(1.803)	(2.857)	(2.136)

Treatment means followed by same alphabet are not statistically significant. Figures in parenthesis are transformed values (Log X + 2).

Table 1 depicts the data on pre-treatment and post-treatment aphid population in different treatments. All the treatments showed superiority over control. On first and 3rd day after spray monocrotophos, chlorpyriphos, methomyl, methyl partathion, dimethoate, phosphamidon, carbaryl and endosulfan treated plants were completely free from aphid population. Fenvalerate and malathion were also at par with these treatments. Observations recorded on 9th and 15th day after spray showed an increasing trend in aphid population in all the treatments, however, monocrotophos was still most effective which recorded least increase in aphid population. This was followed by chlorpyriphos, methomyl and dimethoate which were also at par with monocrotophos at 5% level of significance on 15th day after spray. All the four groups of synthetic pyrethroids were moderately effective. Malathion was least effective which recorded higher aphid population than pre-treatment population. Earlier workers like KLICZA & SAMOL (1969), KLICZA & PALOSZ (1969) and BALASUBRAMANIAM (1974) have also reported dimethoate, parathion, malathion, methyldemeton and carbophenothion initially effective against this aphid which confirms our findings.

Present investigation suggests that the rose aphid can be effectively controlled by alternate sprays of 0.05% monocrotophos and chlorpyriphos at 15 days interval during new growth.

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Entomon 1983, *Vol.* 8, *No.* 3, *pp.* 239 *to* 242

BIO-EFFICACY OF SPRAY APPLICATIONS OF SOME NEWER INSECTICIDES AGAINST SHOOT FLY *ATHERIGONA* SPP. ON PROSO MILLET (*PANICUM MILIACEUM* L.) IN NORTH BIHAR

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Bio-efficacy of three spray applications of four insecticides, *viz.* demeton-S-methyl (25 EC), quinalphos (25 EC), leptophos (35 EC) and endosulfan (35 EC) were tested at three levels of concentrations (0.02, 0.03 and 0.04 per cent) against shoot fly *(Atherigona* spp.) on proso millet *(BR 9)*. The sprayings of either demeton-S-methyl (0.03%) or endosulfan (0.03%) at fortnightly intervals after a fortnight of germination proved effective as well as economic.

(Keywords: Bio-efficacy, shootfly, *Atherigona*, proso millet, *Panicum miliaceum)*

INTRODUCTION

The shoot fly *(Atherigona* spp.), a serious pest of proso millet *(Panicum miliaceum* L.) n Bihar, acts as a major constraint in the maximisation of its yield. Six sprays of endosulfan (0.03%) though controlled shoot fly infestation effectively on sorghum, were reported to be uneconomical (DAVIES & JOWETT, 1970) while application of antifeedants like fentin acetate, fentin-hydroxide and extracts of neem kernels *(Azadiracta indica* L.) over the leaves offered only a partial solution of the pest problem (ABDUL KARIM *et al.*, 1974). Information regarding control of shoot fly on proso millet with particular reference to agroclimatic conditions of North Bihar are lacking in literature. Attempt has, therefore, been made to study the bio-efficacy of spray applications of some newer insecticides against the pest on proso millet. The present paper, therefore, highlights the findings along with the economics of the control measure,

Part of the Ph. D. thesis of the senior author.

MATERIAL AND METHODS

A field trial was conducted at Tirhut College of Agriculture, Dholi, during summer 1980 with four insecticides, *viz.*, demeton-S-methyl (25 EC), quinalphos (25 EC), leptophos (35 EC) and endosulfan (35 EC), each applied at three levels of concentration (0.02, 0.03 and 0.04 per cent). The trial consisted of thirteen treatments including control and was replicated four times in a randomized block design. The plot size was 2.5 × 2.0 m while the spacing between row to row and plant to plant were 22.5 × 10 cm respectively. Fertilizers were applied @ 40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha uniformly at the time of land preparation. Variety *BR 9* of proso millet found susceptible to shoot fly was sown on 15th March. Three applicatians of the insecticides were given at fortnightly intervals starting a fortnight after germination. Observations on the percentage infestation due to the pest were recorded both on the basis of 'deadheart' and 'white earhead'

formation on five randomly selected plant/ plot. The 'deadheart' counts were taken 28 and 42 days after germination while those of 'white earhead', three weeks after panicle initiation stage of the plants. The yield data were also recorded and the economics of insecticidal applications was worked out. The data after being analysed are presented in Tables 1 and 2.

RESULTS AND DISCUSSION

It is evident from the data summarised in Table 1 that all the treatments were statistically superior to control in reducing both the 'deadheart' and 'white earhead'. They, however, proved comparatively more effective initially as is evident from the data. There was significant difference in percentage deadheart when observations were taken 28 DAG and 42 DAG. The low percentage 'dead heart' at 42 DAG and 'white earhead' three weeks after panicle initiation might be due to the toughness of the stems with the advanced age of the corp, thus making difficult for the larvae to develop inside them. All the insecticides when applied at 0.04 per cent concentration failed to express their superiority over their respective strength at 0.03 per cent. Demeton-S-methyl (0.03%), however, significantly proved to be the best treatment giving minimum

TABLE 1. Bio-efficacy of different spray applications of insecticides against shoot fly (*Atherigona* sp.) on proso millet.

Treatment	Concentration (%)	Percentage of deadheart 28 days after germination (DAG)	Percentage of deadheart 42 days after germination (DAG)	Mean percentage of white-earhead	Grain yield (q/ha)
Demeton-S-methyl 25 EC	0.02	16.45 (23.90)	18.57 (25.52)	19.65 (26.27)	16.49
Demeton-S-methyl 25 EC	0.03	10.70 (19.03)	12.22 (20.44)	8.72 (17.11)	17.70
Demeton-S-methyl 25 EC	0.04	19.06 (26.26)	19.45 (26.16)	17.0 (25.16)	15.32
Quinalphos 25 EC	0.02	22.62 (26.56)	21.87 (27.83)	23.25 (28.79)	14.34
Quinalphos 25 EC	0.03	17.62 (24.80)	18.52 (25.48)	20.27 (26.68)	12.32
Quinalphos 25 EC	0.04	21.32 (27.45)	23.52 (28.98)	18.63 (23.03)	12.31
Leptophos 25 EC	0.02	24.02 (29.34)	23.27 (28.79)	21.80 (29.86)	10.64
Leptophos 35 EC	0.03	20.97 (27.20)	23.10 (28.72)	21.90 (27.58)	11.76
Leptophos 35 EC	0.04	17.82 (24.95)	18.42 (25.40)	18.35 (25.36)	10.84
Endosulfan 35 EC	0.02	19.20 (25.94)	19.72 (26.34)	17.45 (24.68)	16.79
Endosulfan 35 EC	0.03	14.20 (22.12)	13.75 (21.73)	10.79 (19.11)	17.43
Endosulfan 35 EC	0.04	19.80 (26.42)	22.87 (28.56)	13.45 (21.46)	15.93
Control		31.78 (34.20)	36.62 (37.23)	29.65 (32.96)	11.27
S E m ±		0.73	1.07	0.83	0.133
C D (P = 0.05)		2.09	3.07	2.38	0.38

(Figures in parentheses are angular transformations)

TABLE 2. Economics of different insectiaidal (emulsifiable concentrate) treatments.

Treatment	Dose	Yield (q/ha)	Additional yield over control	Price of cheena @ Rs. 150·00 per q (Rs)	Cost of insecticide and operation (Rs)	Net return over control (Rs)
Demeton-S-methyl 25 EC	0.02	16.49	5.22	783.00	210 = 00	467 = 00
Demeton-S-methyl 25 EC	0.03	17.70	6.43	965.00	297 = 00	668 = 00
Demeton-S-methyl 25 EC	0.04	15.32	4.05	650 = 00	377 = 00	273 = 00
Quinalphos 25 EC	0.02	14.34	3.07	461 = 00	307 = 00	154 = 00
Quinalphos 25 EC	0.03	12.32	1.05	158 = 00	453 = 00	−295 = 00
Quinalphos 25 EC	0.04	12.31	1.04	156 = 00	559 = 00	−403 = 00
Leptophos 35 EC	0.02	10.64	−0.63	−94 = 50	212 = 00	−306 = 50
Leptophos 35 EC	0.03	11.76	0.49	73 = 00	295 = 00	− 222 = 0
Leptophos 35 EC	0.04	10.84	−0.43	−64 = 50	373 = 00	−287 = 50
Endosulfan 35 EC	0.02	16.79	5.52	825 = 00	207 = 00	621 = 00
Endosulfan 35 EC	0.03	17.43	6.16	924 = 00	287 = 00	637 = 00
Endosulfan 35 EC	0.04	15.93	4.66	699 = 00	363 = 00	336 = 00
Control		11.27				

'deadheart' percentage, ranging from 10.70 to 12.22 while that of 'white earhead' 8.72 per cent with maximum yield (17.70 g/ha). Endosulfan (0.03%) proved to be the second best treatment having 13.75 to 14.20 per cent 'deadheart' and 10.79 per cent 'white earhead', and giving an yield of 17.43 g/ha. The data further indicated the comparative poor performance of leptophos at each level of concentrations both in respect of its bio-efficacy against the fly and yield of the crop.

The data furnished in Table 2 revealed that maximum return (Rs. 668.00/ha) was obtained from demeton-S-methyl (0.03%) followed by endosulfan (0.03%) with a return of Rs. 637.00/ha giving an additional increase of 6.43 and 6.16 g/ha, respectively, over control. Both quinalphos (0.03 to 0.04%) and leptophos (0.02 to 0.04%) exhibited negative correlation between the cost of sprays and additional yield. This might be due to the low market price of proso millet coupled with the poor performance of the aforesaid insecticides in controlling the pest. Therefore, of all the insecticides tested in spray formulations, three sprayings of either demeton-S-methyl (0.73%) or endosulfan (0.03%) at fortnightly interval after a fortnight of sowing proved to be effective as well as economic against the incidence of the fly on proso millet. Davies and Jowett (1970) had advocated six sprays of endosulfan (0.03%) on sorghum against the fly in Eastern Uganda. Proso millet, in Bihar, is being grown as short-duration catch crop during summer occupying a growth period of 90 to 110 days. The ambient temperature and relative humidity during May 1980, were 27.5 ± 9°C and 67 ± 15% R. H. respectively.

The high temperature and low relative humidity at the later stage of plant growth led to toughening of the plant stems making difficult for the larvae to penetrate deep into the plant tissues and develop and as such required comparatively less number of spray applications of insecticidies for the effective control of the fly on proso millet.

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Entomon, 1983, *Vol.* 8, *No.* 3, *pp.* 243 *to* 247

FIELD EVALUATION OF SOME SOIL INSECTICIDES IN RELATION TO WHITE GRUB POPULATION, GERMINATION PLANT STAND AND YIELD OF GROUNDNUT IN U. P., INDIA

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Out of nine soil insecticides tested against white grub, *Holotrichia consanguinea* Blanch. under field conditions in groundnut crop, isofenphos 5G and fensulfothion 5G followed by sevidol 4G and phorate 10G @ 1.5 kg ai/ha proved most effective in reducing the grub population. Similarly isofenphos and fensulfothion reduced plant damage more than 80 per cent followed by sevidol and carbofuran which were having more than 64 per cent reduction in plant damage over control. The yield of groundnut was recorded highest in experimental plots treated with isofenphos (21.8 q/ha) followed by fensulfothion (20.6 q/ha) followed by fensulfothion (20.6 q/ha), sevidol (19.8 q/ha), phorate (19.4 q/ha) carbofuran (18.89 q/ha) and aldrin dust, 16.8 q/ha). Moreover, the treatment of these insecticides does not have any effect on germination of groundnut.

(Key words: field evaluation, soil insecticides, white grub, germination, plant stand, yield, groundnut)

INTRODUCTION

The average yield of groundnut is very low due to white grub attack in several parts of the country viz., Rajasthan, Gujrat, Maharashtra, Karnataka, Tamil Nadu, Bihar, U. P., Punjab, A. P. and Orissa where endemic pockets have developed (DESAI & PATEL, 1965; PATEL *et al.*, 1967; RAI *et al.*, 1969; SRIVASTAVA *et al.*, 1971; MANSOOR ALI, 1974; SRIVASTAVA & MATHUR, 1979). At times, the damage by grubs is so much so that entire stand of crop is destroyed thereby necessiating resowing of the field. The grubs are polyphagous and cosmopolitan in occurrence. Amongst various species of white grubs, *Holotrichia consanguinea* Blanchard causes severe damage to groundnut, pulses, sugarcane, vegetables, cereals and forage crops grown during *kharif* (rainy season). In view of severity of its attack on groundnut crop, the present studies were carried out to evolve an effective control measure against this noxious pest of national importance.

MATERIAL AND METHOD

Granular and dust formulation of nine insecticides viz., isofenphos 5G, phorate 10G, carbofuran 3G, fensulfothion 5G, aldicarb 10G, sevidol 4G, disulfotan 5G (@ 1.5 kg. a i/ha), 10% BHC dust (@ 35 kg/ha) and 5% aldrin dust (@ 26 kg/ha) were applied in the furrows before sowing in the first week of July, 1980 at Groundnut Research Station, Mainpuri (U. P.). The experiment was laid out in Randomized Block Design with three replications and nine treatments in the plots measuring 5 × 5 metre. The treatments and replications were repeated by 0.5 and one metre

bunds respectively. *Chandra* variety of groundnut @ 75 kg kernel/ha was sown in furrows and recommended cultural operations were followed.

The effect of insecticides on germination of groundnut were recorded by counting total number of plants in each experimental plot. White grub population was recorded by digging five soil samples of 30 × 30 × 30 cm area at random in the experimental bed. The data on survival of plant population and white grub population were recorded simultaneously 25, 50 and 75 days after application of insecticides. The data on groundnut yield were recorded separately for each experimental plot and subjected to statistical analysis. (The results thus achieved on various aspects are summarized in Table 1).

RESULTS AND DISCUSSION

It is evident from Table 1 that plant population in different treatments are not significantly different from each other which reveals that insecticidal treatments do not have any effect on germination of groundnut.

Table 1 also indicates that at 25 days after application of insecticides, isofenphos and fensulfothion granules proved most effective and showed more than 80 per cent reduction in grub population followed by sevidol, phorate, carbofuran granules and 5% aldrin dust which were on par. Other insecticides reduced grub population upto 34.86 per cent and all were superior to control. Besides isofenphos and fensulfothion, sevidol and phorate granules gave more than 80 per cent reduction in grub population at 50 days after the application of insecticides followed by carbofuran granules and aldrin dust which were on par. Aldrin granules reduced only 50 per cent of the grub population over control (untreated).

TABLE 1. Effect of insecticides on the germination of groundnut and white grub population.

Treatment	Mean No. of plants	Grub Population					
		25 days after treatment		50 days after treatment		75 days after treatment	
		Mean grub	per cent reduction	Mean grub	per cent reduction	Mean grub	per cent reduction
Isofenphos 5G	203.66	4.00	81.81	2.33	88.72	1.00	91.67
Phorate 10G	204.66	5.00	77.27	3.66	82.28	2.66	77.83
Carbofuran 3G	194.00	6.66	69.72	4.33	79.04	3.66	69.50
Fensulfothion 5G	202.66	4.33	80.09	3.00	85.48	1.33	88.92
Aldicarb 10G	200.66	14.33	34.86	10.33	50.00	7.33	38.92
Sevidol 4G	204.00	4.66	78.81	2.66	87.12	1.66	86.17
Disulfotan 5G	197.66	11.66	47.00	8.00	61.28	6.66	44.50
10% BHC dust	206.80	9.00	59.09	6.33	69.36	5.00	58.33
5% Aldrin dust	195.00	7.66	65.18	5.00	75.80	4.00	66.67
Control (untreated)	195.66	22.00	—	22.66	—	12.00	—
S E M ±	—	0.39	—	0.39	—	0.45	—
C D at 5% level	—	0.83	—	0.82	—	0.95	—

TABLE 2. Effect of white grub *H. consanguinea* on the plant stand and yield of groundnut.

Treatment	25 days after treatment		50 days after treatment		75 days after treatment		Yield	
	Mean damage	per cent reduction in plant damage over control	Mean damage	per cent reduction in plant damage over control	Mean damage	per cent reduction in plant damage over control	Average yield kg/plot	per cent increase in yield over control
Isofenphos 5G	3.79	93.11	8.56	86.44	10.20	84.89	5.450	411.74
Phorate 10G	25.52	93.62	34.76	44.95	38.90	42.36	4.850	355.40
Carbofuran 3G	17.70	67.83	20.22	67.97	23.87	64.63	4.723	343.43
Fensulfothion 5G	4.64	91.57	8.58	84.60	13.15	80.51	5.150	383.56
Aldicarb 10G	30.02	45.44	37.22	41.05	49.12	27.22	2.450	130.04
Sevidol 4G	13.90	74.74	16.54	73.80	19.65	70.88	4.973	366.90
Disulfutan 5G	20.05	63.56	42.89	32.07	58.86	12.79	3.050	186.38
10% BHC Dust	22.96	58.27	31.09	50.76	39.39	41.63	3.300	209.86
5% Aldrin dust	26.27	52.25	35.10	44.41	42.32	37.29	4.200	294.36
Control (untreated)	55.02	—	63.14	—	67.49	—	1.066	—
S E M ±	4.00	—	5.08	—	7.20	—	0.710	—
C D at 5%	8.42	—	10.67	—	15.13	—	1.492	—

At 75 days after application, isofenphos, fensulfothion and sevidol granules were on par with phorate G and aldrin dust and reduced the grub population upto 66.67 per cent. Disulfotan and aldicard granules were less effective.

The overall assessment of insecticides in terms of their effectiveness for reducing grub population showed that isofenphos and fensulfothion were most effective followed by sevidol and phorate granules. BAKHETIA & SUKHIJA (1978), DWIVEDI *et al.*, (1976), BHATNAGAR *et al.*, (1975), MANSOOR ALI (1974), YADAVA & YADAVA (1973) and SRIVASTAVA *et al.*, (1971) found fensulfothion, phorate and carbofuran granules were effective in reducing the grub population.

It is evident from Table 2 that at 25 days after insecticidal treatment, the percentage of plant damage was least in plots treated with isofenphos followed by fensulfothion i. e. 93.11 and 91.57 per cent respectively. Sevidol, carbofuran, disulfotan granules and BHC dust were also effective in reducing per cent plant damage, but do not differ significantly among themselves. The reduction in plant damage at 50 days after application of insecticides was more than 73.80 per cent in plots treated with isofenpohs, fensulfothion and sevidol granules followed by carbofuran G and BHC dust with 67.96 and 50.76 per cent decrease in plant damage respectively. The other chemicals were not much affective in reducing the plant damage.

The reduction in plant damage at 75 days after application of insecticides was more than 64.63 per cent in plots treated with isofenphos, fensulfothion, sevidol and carbofuran granules which were statistically on par, whereas disulfotan and aldicarb granules treated plots showed least reduction in plant damage which was almost equal to control (untreated).

The overall effect of insecticides on reduction in plant damage was more than 80 per cent in experimental plots treated with isofenphos and fensulfothion followed by sevidol and carbofuran granules which showed more than 64 per cent reduction in plant damage over control but other insecticides gave below 43 per cent.

The yield of groundnut was highest in experimental plots treated with isofenphos (21.8 q/ha) followed by fensulfothion (20.6 q/ha), sevidol (19.8 q/ha), phorate (19.4 q/ha), carbofuran (18.89 q/ha) and aldrin dust (16.8 q/ha). The highest yield in case of isofenphos, fensulfothion, sevidol and phorate granules treated plots were the direct outcome of the better protection provided to the crop against white grub *H. consanguinea* by these insecticides. The increase in yield over control was recorded 411.74 per cent in isofenphos, 383.56 per cent in fensulfothion, 366.90 per cent in sevidol and 355.40 per cent in phorate granules treated plots. Dwivedi *et al.*, (1976) also obtained more or less similar results and reported higher yield of groundnut in case of phorate followed by fensulfothion granules.

The experimental findings conclude that the use of isofenphos 5G or fensulfothion 5G or Sevidol 4G or Phorate 10G @ 1.5 kg. a. i./ha in furrows at the time of sowing has effectivly reduced white grub population without affecting germination and increasing thereby groundnut yield.

Besides, beetles should also be controlled by spraying host trees with a more effective insecticides at the time of their first insurgence before oviposition for supperessing the grub population.

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NATURAL ENEMY COMPLEX OF THE TEAK SKELETONIZER, *PYRAUSTA MACHAERALIS* WALKER (LEPIDOPTERA : PYRALIDAE) IN KARNATAKA[1]

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In a survey for the natural enemies of the teak skeletonizer, *Pyrausta machaeralis* Walker (Lepidoptera : Pyralidae) in different forests of Karnataka, South India during 1978 to 1980 43 species of parasitoids, 60 species of predators, three species of insect pathogens of different groups and eight species of hyperparasites were collected. The distribution of these natural enemies along with the predominent parasitoids in different forests of Karnataka is presented.

(Key words: natural enemy complex, teak skeletonizer, *Pyrausta machaeralis)*

INTRODUCTION

The teak skeletonizer, *Pyrausta* (= *Hapalia*) *machaeralis* Walker is one of the serious insect pests of teak. This is known to occur in the teak forests of India, Burma, Ceylon, Indochina and the region from the Malayasia to Australia (BEESON, 1941).

It affects teak plants adversely and the periodic outbreaks cause considerable loss of increment and quality. Survey for the skeletonizer and its natural enemies has been made by earlier workers in natural forests and in the teak plantations of Madhya Pradesh, Kerala, Karnataka, Tamilnadu and Maharashtra and the parasites were also bred (HOLE, 1904; STEBBING, 1908; BEESON, 1928, 1938; BEESON & CHATTERJEE, 1939; GARTHWAITE & DESAI, 1939; MATHUR, 1947, 1960). But a detailed survey of the insect pest and its natural enemies particularly in different forests of the Karnataka state was completely wanting (MATHUR, 1977), which was conducted during this investigation, the results of which are presented here.

MATERIAL AND METHODS

All types of forests found in Karnataka were surveyed for the natural enemy complex of the teak skeletonizer, *P. machaeralis* in all the three seasons for two years. The forests selected were Prabhunagar (moist deciduous forest), Azagoan (moist deciduous forest), Kakthi (moist deciduous forest), Honnavar (dry deciduous forest), Kumsi (moist deciduous forest), Tolguppa (semi evergreen forest), Mercera (wet evergreen forest) and Tithimatti (wet evergreen forest). The surveys were undertaken during second fortnights of June, October and January of 1978—1979 and also in 1979—1980. The larvae collected at different localities during sampling for natural incidence of *P. machaeralis* (Patil and Thontadarya, 1983) were brought to the laboratory and bred for recording the parasites. Predators and pathogens were also recorded from different localities. They were cultured further in the

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laboratory for establishing their identity and also their predatory nature and pathogenicity respectively.

RESULTS AND DISCUSSION

In all, 106 natural enemies of *P. machaeralis* and eight species of hyper parasites were collected during the period of investigation. Totally 43 species of parasites were bred from the teak skeletonizer collected from different forests of Karnataka and it includes 25 species of larval and 18 species of pupal parasites. The distribution of these parasites in different forests is tabulated in Table 1.

TABLE 1. List of insect parasites bred from *Pyrausta machaeralis* Wlk and hyperparasites collectd in different forests of Karnataka during 1978—1980.

Sl. No.	Scientific name	Different forest localities of Karnataka							
		Prabhu-nagar	Aza-goan	Kak-thi	Hon-navar	Kum-si	Tol-guppa	Mer-cera	Tithi-matti
1	2	3	4	5	6	7	8	9	10
A)	*Larval parasites*								
	Order : Hymenoptera								
	Family : Braconidae								
1.	*Apanteles glomeratus* Linn.*	P	P	A	A	A	A	A	A
2.	*A. machaeralis* Wilkinson	P	P	P	P	P	P	P	P
3.	*A. mycetophilus**	P	A	P	P	A	A	A	A
4.	*A. ruidus* Wilkinson	A	A	A	A	P	P	A	A
5.	*Cremnops atricornis* Smith*	P	P	P	P	A	A	A	A
6.	*Iphiaulax* sp*	P	A	A	A	A	A	A	A
7.	*Microplitis maculipennis* Szepligeti*	A	A	P	A	A	P	A	A
8.	*Microgaster indicus* Wilkinson	P	P	P	P	P	P	P	P
9.	*Phanerotoma hendecasisella* Cameron	P	P	P	P	P	p	P	P
10.	*Phanerotoma* sp*.	P	A	A	A	A	A	A	A
11.	Unidentified species	A	P	P	A	P	A	A	P
12.	Unidentified species	A	A	A	A	P	P	A	A
13.	Unidentified species	P	A	A	A	A	A	A	A
	Family : Encyrtidae								
14.	*Litomastix* sp*	P	A	A	A	A	A	A	A
	Family : Ichneumonidae								
15.	*Cremastus hapaliae* Cushman	P	P	P	P	P	P	P	P
16.	*Diadegma* sp*	P	P	P	A	A	A	A	A
17.	*Eriborus trochanteratus* (Morley)*	P	A	P	P	A	A	A	A
18.	*Goryphus zonalis* Townes &Gupta*	P	A	A	A	A	A	A	A
19.	*Microtoridea secunda* Cushman*	A	P	P	A	P	P	A	A
20.	*Mesostenus* sp*	P	P	P	P	P	P	P	P
21.	*Trathala flavoorbitalis* (Cameron)*	P	P	P	P	P	P	P	P
22.	*Trichomma nigricans* Cameron	P	P	P	P	P	P	P	P
23.	*Triclistus* sp*.	P	A	A	P	P	P	P	P
24.	*Trophocamps indubia* Morley	P	P	P	P	P	P	A	A
25.	Unidentified species	P	A	P	A	P	A	A	P

Table - I Continued

1	2	3	4	5	6	7	8	9	10
B.	*Pupal parasites*								
	Family : Chalcidae								
26.	*Brachymeria euploeae* Westwood	P	P	P	P	P	P	P	P
27.	*B. criculae* (Kohl)*	P	P	P	P	P	P	A	A
28.	*B. nephantidis* Gahan	A	A	A	P	P	P	P	P
	Family : Eulophidae								
29.	*Trichospilus pupivora* Ferr	A	A	A	P	P	P	A	A
	Family : Ichneumonidae								
30.	*Xanthopimpla cera* Cameron	P	P	P	P	P	P	P	P
	Order : Diptera								
	Family : Tachinidae								
31.	*Actia* sp.	A	A	A	P	P	A	A	P
32.	*Argyrophylax nigritibialis* Baranoff	P	P	P	P	P	P	P	P
33.	*Carceliella octava* Baranoff	P	A	A	A	P	A	P	P
34.	*Cadurcia vanderwalpi* Baranoff	A	P	A	A	P	P	A	P
35.	*Compsilura concinnata* (Wiedemann)*	P	A	A	A	A	A	P	P
36.	*Dolichocolon orbitable* Baranoff	P	P	A	A	P	P	P	P
37.	*Eutapalivora indica* Baranoff	A	A	A	A	P	P	A	A
38.	*Hapaliolaemus machaeralis* Baranoff	P	A	A	A	P	P	A	A
39.	*Palexorista laxa* Curran*	P	P	P	P	P	P	P	P
40.	*Ptychomyia remota* Aldrich	A	A	A	P	A	P	A	P
41.	*Sturmia nigribarbis* Baranoff	P	P	P	P	P	P	P	P
42.	*Sturmia* sp.	P	A	A	A	A	A	P	P
43.	Unidentified species	P	A	A	A	A	A	A	A
C.	*Hyperparasites:*								
	Order : Hymenoptera								
	Family : Chalcidae								
44.	*Dirhinus excavatus* Dalman	A	P	P	P	P	P	P	P
	Family : Elasmidae								
45.	*Elasmus brevicornis* Gahan	P	P	P	P	P	P	P	P
	Family : Eulophidae								
46.	*Nesolynx thymus* (Girault)*	P	A	P	A	A	A	A	A
47.	*Tetrastichus ayyari* Rohwer*	P	P	P	A	A	A	A	A
48.	*Tetrastichus* sp.	P	A	A	P	P	P	P	P
	Family : Eurytomidae								
49.	*Eurytoma braconidis* Ferriere	A	A	P	P	A	A	A	A
	Family : Perilompidae								
50.	*Perilampus microgastris* Ferriere	P	A	A	A	P	P	P	P
51.	*Perilampus* sp.	P	A	A	A	P	P	P	P

P = Present, A = Absent, * New host record.

Present studies have also revealed the predominant parasites and hyperparasites in different forests of Karnataka. In Prabhunagar and Azagoan forests, the parasites, *Apanteles machaeralis* Wlk, *Trathala flavoorbitalis* (Cam), *Phanerotama hendecasisella* Cam., *Crennops atricornis* Smith and *Argyrophylax nigritibialis* Bar. were more predominant and their population varied considerably from generation to generation. Unfortunately, the hyperparasites, *Elasmus brevicornis* Gah., which was recorded from larval parasites *A. machaeralis*, *T. flavoorbitalis* and *P. hendecasisella*; *Nesolynx thymus* (Gir) which was recorded from larval parasites *P. hendecasisella* and *C. atricornis;* and *Tetrastichus ayyari* Rohwer which was recorded from pupal parasite *A. nigritibialis* were also more predominant in these forests. In Azagoan forest, the hyperparasite, *Perilampus microgastris* Ferr, which was recorded from larval parasites was also predominant which was not seen in Prabhunagar forest.

In Kakthi forest, the parasites, *A. machaeralis*, *P. hendecasisella*, *Brachymeria euploeae* West., *A. nigritibialis* and the hyperparasites, *Dirhinus excavatus* Dal., which was recorded from larval parasites *A. machaeralis* and *P. hendicarsella.*, *E. brevicornis* and *P. microgastris* were also predominant. Whereas, in Honnavar forest, the parasites, *A. machaeralis*, *P. hendecasisella*, *C. hapaliae* Cush, *B. euploeae*' *B. nephantidis* Gah., *Sturmia nigribarbis* Barcancoff and the hyperparasites, *E. brevicornis* and *Tetrastichus* sp. which was recorded from pupal parasites *S. nigriburbis* and *Brachymeria* spp. were more predominant.

In Kumsi and Tolguppa forests, the parasites *A. machaeralis*, *Microgaster indicus* Wilk., *C. hapaliae*, *Trichospilus pupivora* Ferr., *Actia sp.*, *M. secunda* Cush., and the hyperparasites, *D. excavatus*, *E. brevicornis* and *Perilampus* sp. were more predominant. Similarly, in Mercera and Tithimatti forests, the parasites, *A. machaeralis*, *M. indicus*, *C. hapaliae*, *B. euploeae*, *Dolichocolen orbitale* Bar.. *S. nigribarbis*, *Actia* sp. and the hyperparasites, *D. excavatus*, *P. microgastris* and *E. brevicornis* were more predominant than other parasite species. These present observations are in accordance with the reports of BEESON (1938) who has given a distribution chart of different species of the parasitoids of *P. machaeralis* which occur in India. However, the presen studies have slightly differed in respect of the occurrence (new host record of some parasite species) and predominance of some parasite species. Further, the present study covered different forest areas of Karnataka state, whereas he had confined to Coorg as a representative forest area for survey of natural enemies.

During the period of survey, 60 species of predators were noticed from differert forests of Karnataka. These include nine species of preying mantids six species of reduvids, two species of coccinellids, four species of ants and 37 species of spiders. Their distribution among different forests is presented in Table 2. The predatory habit of each species of predator on the skeletonizer larvae was also studied in the laboratory condition. The mantids, reduviids, ants and spiders fed on both young and grown up larvae of *P. machaeralis*, whereas the two coccinellid adults *(J. soror* and *S. binotata)* were found feeding only on the eggs. Among the predators, spiders were found to be predominant in all the forests followed by mantids. HOLE

TABLE 2. List of predators of *Pyrausta machaeralis* Wlk. recorded from different forests of Karnataka during 1978—1980.

Sl. No.	Scientific name	Different forest places of Karnataka							
		Prabhu-nagar	Aza-goan	Kak-thi	Hon-navar	Kum-si	Tol-guppa	Mere-era	Titti matt
1	2	3	4	5	6	7	8	9	10
A.	*Preying mantids:* Order : Dictyoptera Family : Mantidae								
1.	*Creoboter urbana* Fabricius	A	P	P	P	A	P	P	P
2.	*Creoboter* sp.	P	P	P	P	P	P	P	P
3.	*Euantissa ornata* Werner	P	A	A	A	A	A	A	A
4.	*Gonypeta punctata* Hean	A	P	P	P	A	A	A	A
5.	*Hierodula ventralis* Giglio-Tos	P	P	A	A	A	P	A	A
6.	*Hierodula* sp.	P	P	P	A	P	P	P	P
7.	*Humbertiella* sp.*	P	P	P	P	P	A	A	P
	Family : Hymenopodiadae								
8.	*Ephestiasula* sp.*	P	P	A	A	A	A	P	P
9.	*Hestiasula* sp.	P	P	A	A	A	A	P	A
B.	*Reduviid bug:* Order : Hemiptera Family : Reduviidae								
10.	*Alcmena* sp.*	P	P	A	A	A	A	A	A
11.	*Ectomocoris cordiger* Stal*	A	A	A	A	P	A	A	A
12.	*Cydnocoris gilvus* (Burm.)*	P	P	A	A	P	P	P	P
13.	*Oncocephalus impudicus* Reut*	P	A	A	A	A	A	A	A
14.	*Sycanus collaris* Fabricius	A	A	A	A	A	A	A	P
15.	*Sycanus* sp.	A	A	A	A	A	A	A	P
C.	*Coccinellids;* Order : Coleoptera Family : Coccinellidae								
16.	*Jauravia soror* (Weise) *	P	P	A	A	A	P	A	A
17.	*Sticholotis binotata* (Gorham) *	P	P	P	A	A	P	A	A
D.	*Ants:* Order : Hymenoptera Family : Formicidae								
18.	*Camponotus sericeus* (Fabricius) *	P	P	P	P	P	P	A	A
19.	*Camponotus* Sp. *	P	P	P	P	P	P	P	P
20.	*Pheidole* sp. *	P	P	P	P	P	P	P	P
21.	*Pheidole* sp. *	P	P	P	P	P	P	P	P
E.	*Spiders:* Family : Agelenidae								
22.	*Tegeneria* sp. *	A	A	A	P	A	P	P	P
	Family : Araneidae								
23.	*Leucauge tessellata* (Thorell) *	P	P	P	A	A	A	A	A
24.	*Neoscona achine* (Simon) *	P	P	A	A	A	A	A	A
25.	*N. excelsus* (Simon) *	P	A	P	A	P	P	A	A

Table—2 Continued

1	2	3	4	5	6	7	8	9	10
26.	*N. theis* (Walckenaer) *	P	A	A	A	A	A	P	P
27.	*N. lugubris* (Walckenaer) *	A	A	A	A	A	A	P	P
28.	*N. rumpfi* (Thorell) *	P	P	P	P	P	P	P	P
	Family : Clubionidae								
29.	*Cestineira* sp. *	P	P	A	A	A	P	P	A
30.	*Chiracanthium* sp. *	A	A	A	P	P	P	A	A
31.	*Clubiona* sp. *	P	P	P	P	P	P	P	P
	Family : Heteropodidae								
32.	*Heteropoda* sp. *	P	P	P	P	P	P	P	P
	Family : Linyphiidae								
33.	*Linyphia urbasae* Tikader *	A	A	P	A	A	A	A	A
	Family : Oxyopidae								
34.	*Oxyopes birmanicus* Thorell	P	P	P	P	P	P	P	P
35.	*Peucetia latikae* Tikader *	A	A	A	A	A	A	P	P
36.	*Oxyopes* sp. *	A	A	A	A	P	P	A	A
	Family : Pisauridae								
37.	*Tinus sikkimensis* Tikader *	P	P	P	P	P	P	P	P
	Family : Salticidae								
38.	*Harmochirus brachiatus* (Thorell)*	P	A	A	A	A	P	A	P
39.	*Marpissa bengalensis* Tikader *	P	P	P	P	P	P	P	P
40.	*M. calcuttaensis* Tikader *	A	A	A	A	P	P	A	A
41.	*M. decorata* Tikader *	P	P	P	A	P	P	A	A
42.	*M. dhakuriaensis* Tikader *	P	P	P	A	A	A	A	A
43.	*Maripissa* sp. *	P	A	A	A	P	P	A	P
44.	*Myrmaracne bengalensis* (Tikader)	P	P	P	P	P	P	P	P
45.	*M. orientales* Tikader *	A	A	A	P	P	P	A	A
46.	*Myrmarachne* sp. *	A	A	A	P	P	P	A	P
47.	*Phidippus bengalensis* Tikader *	P	P	P	P	P	P	P	P
48.	*P. pateli* Tikader *	P	P	P	P	P	P	P	P
49.	*P. punjabensis* Tikader *	A	A	A	A	A	A	P	P
50.	*Plexippus paykulli* (Aud.) *	A	A	A	A	P	P	P	P
	Family : Sparasidae								
51.	*Sparassus lamarcki* Latrelle *	P	P	A	A	A	A	A	A
52.	*S. wroughtoni* Simon *	A	A	A	A	P	P	P	P
53.	*Sparassus* sp. *	P	A	P	A	P	A	P	P
	Family : Theridiidae								
54.	*Argyrodes andamanensis* Tikader *	P	P	P	P	P	P	P	P
55.	*Argyrodes* sp. *	P	A	P	A	P	P	A	P
56.	*Dryapetisca* sp. *	P	A	P	P	A	A	P	P
57.	*Theridion* sp. *	P	P	A	A	P	P	P	P
	Family : Thomisidae								
58.	*Thomisus dhakuriaensis* Tikader *	A	P	A	A	A	P	A	P
59.	*T. shillongensis* sen *	A	P	A	A	A	P	A	P
60.	*Thomisus* sp. *	P	P	P	A	A	P	A	P

P = Present, A = Absent, * = New host record

(1904), STEBBING (1908), BEESON (1928) and MATHUR (1960) have similarly reported and recognised the important role played by these spiders.

The fungal pathogen, *Beauveria bassiana* (Bals.) Vuill in Kumsi and Tolguppa forests and two bacterial pathogens, *Bacillus cereus* Frankland and and *Serratia marcescens* Bizio were found infecting the larvae of *P. machaeralis* in Prabhunagar forest. Earlier, infection of skeletonizer larvae by an unidentified entomogenous fungus has been reported (ANONYMOUS, 1978).

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Entomon, 1983, *Vol.* 8, *No.* 3, *pp.* 257 *to* 261

PREDICTION OF THE MANGO HOPPER, *IDIOSCOPUS CLYPEALIS* LETH. POPULATION IN RELATION TO PHYSICAL ENVIRONMENTAL FACTORS

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The mango hopper, *Idioscopus clypealis* Leth. is most serious insect pest of mango in South East Asia and causes serious losses to the crop. From the studies conducted on mango hopper population in relation to physical environmental factors and its prediction, it was found that hopper population was at peak during March-April, while lowest during December-January. Temperature and percentage relative humidity together have much influence on hopper population development. A quadratic fit through maximum, minimum temperatures and relative humidity was most reliable and explained 89% of the variation in the hopper population.

key words: Mango leaf hopper, *Idioscopus clypealis*, population prediction, physical and environmental factors.

INTRODUCTION

The Cicadellid, *Idiosoopus clypealis* Leth. is the most serious insect pest of mango in India and other South East Asian countries (TANDON & LAL, 1979). The nymph and adult hoppers suck sap from the tender leaves and inflorescences, as a result of which the infested tissues get dried and finally fruit set is affected. A knowledge of insect population fluctuation on its host in relation to physical environmental factors is quite useful for predicting pest population and ultimately in pest management. Perusal of the literature revealed that no systematic studies have been conducted on this pest except only 9 months observations taken by SOOD *et al.*, 1971.

Contribution No. 969 of Indian Institute of Horticultural Research 255, Upper Palace Orchards, Bangalore-560006.

MATERIALS AND METHODS

The studies on the prediction of *I. clypealis* population in relation to physical environmental factors viz. maximum temperature (X_1,) minimum temperature (X_2), average temperature (X_3), per cent relative humidity (X_4) and rain fall (X_5) were conducted in a grower orchard at Golakuan (Lucknow) U. P. during 1976 on ten trees of Dashehari cultivar. Ten shoots (10 cm long) around on each tree were tagged for taking observations on hopper population (Y) at weekly interval. Simultaneously, observations on meteorological factors ie. maximum and minimum temperatures, relative humidity and rainfall were recorded daily. Monthly average were calculated of all these factors before their statistical analysis. All the possible distinct correlations (15 in all) among the above mentioned six variables were worked out. Further, by using the method of least squares, one multiple linear regression equation and five second degree equations were fitted taking meteorological factors as independent variables for predicting the hopper population (SNEDECOR & COCHRAN, 1967). These equations were as below:

TABLE 1. Seasonal Population fluctuation of mango hopper, *Idioscopus clypealis* Leth. Population in relation to physical environmental factors.

Month	Av. Hopper population/ Shoot (Y)	Temperature °C			Av. R.H.% (X_4)	Total rainfall in cm. (X_5)
		Max. (X_1)	Min. (X_2)	Av. (X_3)		
January	0.70	21.67	5.58	13.63	70.95	0.00
February	1.16	25.51	6.83	16.17	65.98	0.00
March	36.43	31.56	12.09	21.83	52.93	0.00
April	20.22	37.65	19.71	28.60	47.51	0.18
May	6.08	38.93	22.27	30.69	54.09	0.78
June	3.02	37.64	24.56	31.10	67.01	4.26
July	3.51	34.72	25.90	30.31	76.14	26.70
August	4.10	29.51	24.71	27.11	87.76	20.69
September	1.83	32.47	23.71	28.09	78.91	5.45
October	3.68	33.96	16.34	25.15	66.73	0.00
November	1.26	29.36	11.30	20.58	70.06	0.00
December	0.47	23.88	5.24	14.56	67.92	0.00
Mean	6.87	31.40	16.56	23.98	67.17	4.8

TABLE 2. Correlation Matrix

Av. Hopper Population (P)	Max. Temp. (X_1)	Min. Temp. (X_2)	Av. Temp. (X_3)	R. H. (%) (X_4)	Rainfall (X_5)
X_1 0.2397 (8.39%)	1.0000				
X_2 0.0083 (Negligible)	0.7999++	1.0000			
X_3 0.1318 (1.67%)	0.9292++	0.9651+	1.0000		
X_4 —0.6362+ (40.48%)	—0.3746	0.2097	—0.0345	1.0000	
X_5 —0.1765 (3.11%)	0.1579	0.6231	0.4533	0.6281+	1.0000

Figures in parenthesis explain about the percentage variation in hopper population contributed by the factors.

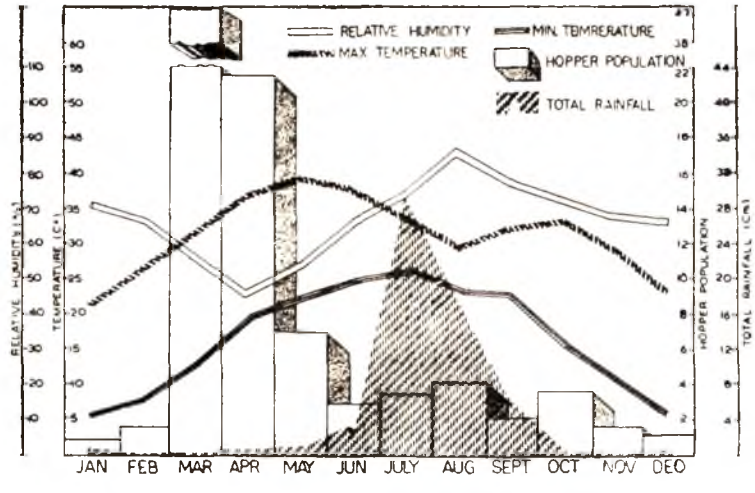
1. A quadratic fit with average temperature—f (X_3' X^2_3)
2. A quadratic fit with maximum and minimum temperatures—f (X_1' X^2_1' X_2' X^2_2)
3. A linear fit with maximum, minimum temperatures, percentage relative humidity and rainfall f (X_1' X_2' X_4' X_5)
4. A quadratic relation with average percentage relative humidity—f (X_4' X^2_4)
5. A quadratic relation with average temperature and percentage relative humidity f (X_3' X^2_3' X_4' X^2_4)
6. A quadratic fit with maximum and minimum temperature and percentage relative humidity—f (X_1' X^2_1' X_2' X^2_2' X_4' X^2_4)

RESULTS AND DISCUSSION

The data presented in the Table 1 regarding monthly average hopper population/shoot (Y) and maximum temperature (X_1), minimum temperature (X_2), average temperature (X_3), percentage relative humidity (X_4) and rainfall (X_5) along with their mean values and graphical representation (Fig. 1) of the same clearly indicate that during March—April the hopper population was maximum while during cold months ie. of December—January, it was lowest. This peak period coincides with the flowering season. CHICH & LEE (1978) reported similar observations in case of *Idioscopus niveosparsus* Leth from Thaiwan.

Table 2 presents a correlation matrix consisting of 15 distinct correlations among the different environmental factors alongwith hopper population. It is evident from the data that there was a significant negative correlation between hopper population and percentage relative humidity ($r = -0.6362$). Among other factors, maximum, minimum and average temperatures had positive significant correlations among themselves and also relative humidity had a positive correlation with rainfall ($r = +0.6281$).

Based on the correlations presented in Table 2 and curves obtained in Fig. 1,



an attempt was made to predict the average hopper population through meteorological factors by fitting a linear and 5 quadratic regression equations. Since the percentage relative humidity had a significant correlation as also the temperature being very specific in predicting the hopper population, only these factors

TABLE 3. Regression Equations

Max. Temp. X_1(1)	Max. Temp.^{2} X^2_1(2)	Min. Temp. X_2(3)	Min. Temp.^{2} X^2_2(4)	Av. Temp. X_3(5)	Av. Temp.^{2} X^2_3(6)	% R.H. X_4(7)	% R.H. X^2_4(8)	Rain-fall X_5(9)	Inter-cept a (50)	R^2— value in % (11)	Adequacy of F-test (12)
—	—	—	—	7.4494	—0.1608	—	—	—	— 73.15	19.46	N.S.
5.1946	—0.0668	1.4196	—0.0670	—	—	—	—	—	—109.76	32.34	N.S.
—2.4042	—	1.6074	—	—	—	—1.4073	—	0.2569	149.05	56.36	N.S.
—	—	—	—	—	—	—4.6892	0.0307	—	179.69	59.39	+
—	—	—	—	5.4155	—0.1223	—4.1145	0.0264	—	106.23	69.40	+
7.8262	—0.2320	6.5217	—0.0694	—	—	—0.0411	—0.0186	—	0.53	88.91	+

N. S. = Not Significant; + Significant at 5% level: Columns 1–10 indicate Partial Regression Coefficients.

were taken as independent variables in different forms and six types of equations were fitted. The partial regression coefficients, percentage multiple determination values (R^2) and adequacy of 'F' test for the above fits were presented in Table 3. The linear relation corresponding to maximum temperature and relative humidity explained 8.39% and 40.48% of variation in hopper population while the contribution of other factors was negligible.

The quadratic fits corresponding average, maximum and minimum temperature and linear fit with maximum minimum temperatures, relative humidity and rainfall were found to be most significant as evident by the adequacy of F-tests. Average temperature could explain only 19.46%, maximum and minimum temperatures explained 32.34% and other four factors i. e. X_1' X_2' X_3 and X_5 through their linear form contributed only 56.36% towards changed in hopper population. The latter three equations 4, 5 and 6 viz. f (X_4' X^2_4); F (X_3' X^2_3' X_4' X^2_4) and f (X_1' X^2_1' X_2' X^2_2' X_4' X^2_4) were also found to be significant at 5% level. Percentage relative humidity through a parabolic fit explained 60% of variation while quadratic fit corresponding to average temperature and relative humidity accounted for 69% variation in hopper population. The maximum and minimum temperatures and relative humidity explained 89% towards the same through a quadratic fit. Among the different equations fitted, the partial regression coefficient corresponding to the linear component of the quadratic fit with relative humidity alone was found to be siginificant at 5% level and the quadratic component missed the 5% level very narrowly.

From the above results, it can be concluded that hopper population which is found at peak during March-April and lowest during December-January have been much influenced by temperature and relative humidity together. For predicting hopper population, it was found that a quadratic fit through maximum, minimum temperatures and relative humidity was most reliable followed by the quadratic fit through only percentage relative humidity.

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RECORD OF NEW ERIOPHYID MITES (ERIOPHYOIDEA : ACARINA) FROM SOUTH INDIA

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The paper presents the descriptions of three species of mites namely *Eriophyes rotundae*, sp. nov; *E. euphorbiae* sp. nov; *E. plectroniae* sp. nov; belonging to the family Eriophyidae and one species *Stenarhynchus aristidus* gen. et sp. nov. belonging to Rhyncaphytoptidae. Among these, *E. rotundae* sp. nov. is unique for the presence of gigantic forms among its population whose measurements also have been given. All the species have been adequately illustrated.

(*Key words:* Eriophyidae: Eriophyes: Rhyncaphytoptidae, Stenarhynchus.)

In this paper four species of mites are described as new to science, among which one species forms a new genus. The species have been adequately sketched and their affinities to the closely related species given.

The type and paratype slides have been deposited in the collections of the Department of Entomology, Tamilnadu, Agricultural University, Coimbatore - 641 003. India (TNAU)

1. Eriophyes rotundae, Sp. nov. (Fig. 1)

This species resembles *Eriophyes cyperi* Channabasavanna (1966) in its median and admedian lines on the shield but could be differentiated from it by the characteristic feather claw with its distal ray elongated, the non granular sides of shield, and the occurrence of gigantic forms in the population.

Female: 180-190 long. worm like 40 thick. rostrum 15 long evenly downcurved; antapical seta 5 long. Median nearly complete except for the anterior end, admedians complete, fiirst submedian curved and represented in the enterior half, second submedian similar to first, third submedion and fourth submedian short, fused at the rear end, first submedian broken, forms the border of the shield; sides of shield granular. Dorsal tubercles 15 apart, away from shield margin, dorsal seta 7 long, pointing upward and forward. Foreleg 22 long, tibia 5 long, tibial seta 4 long, tarsus 6 long, claw 5 long, feather claw 4 rayed, distal ray elongated. Hindleg 22 long, tibia 5 long, tarsus 6 long, claw 5 long coxae with a clear sternal line, all three setiferous tubercles present, tubercle I at about middle of forecoxae tobercle II near base of forecoxae: tubercle III in the basal half of hind coxae; caval area with sparse scorings. Abdomen with about 70 rings, uniformly microtuberculate, microtubercles oval, placed along the posterior margin of each ring; lateral seta 20 long on ring 10; first ventral seta 15 long on ring 20; second ventral seta 10 long on ring 38; third ventral seta 27 long on ring 6 from

All measurements given are in micra.

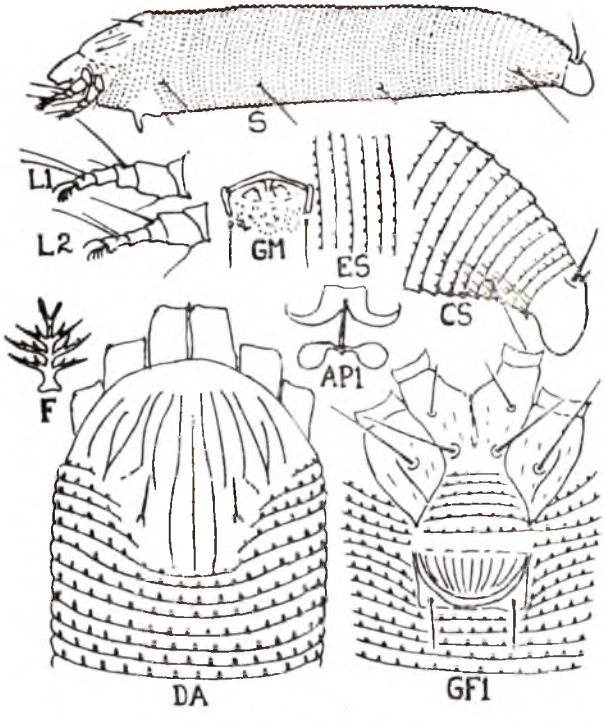

Fig. 1. *Eriophyes rotandae* sp. nov.

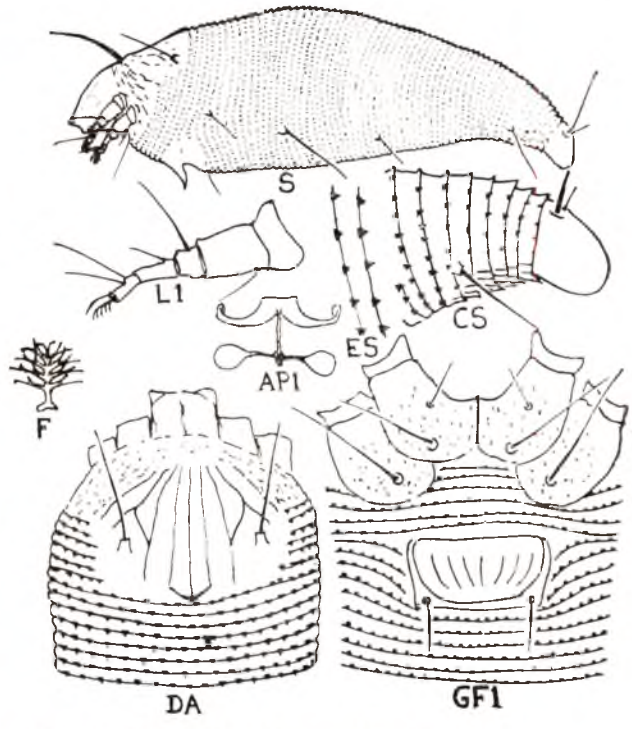

Fig. 2. *Eriophyes euphorbiae* sp. nov.

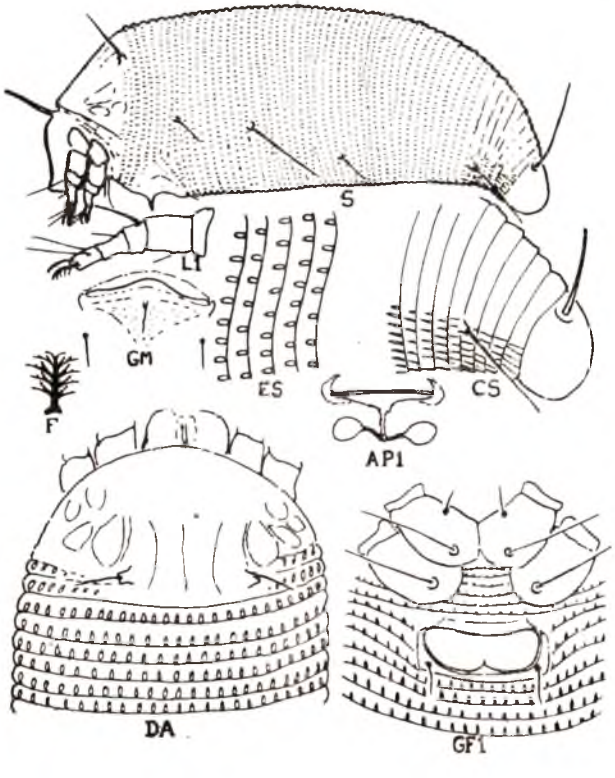

Fig. 3. *Eriophyes plectroniae* sp. nov.

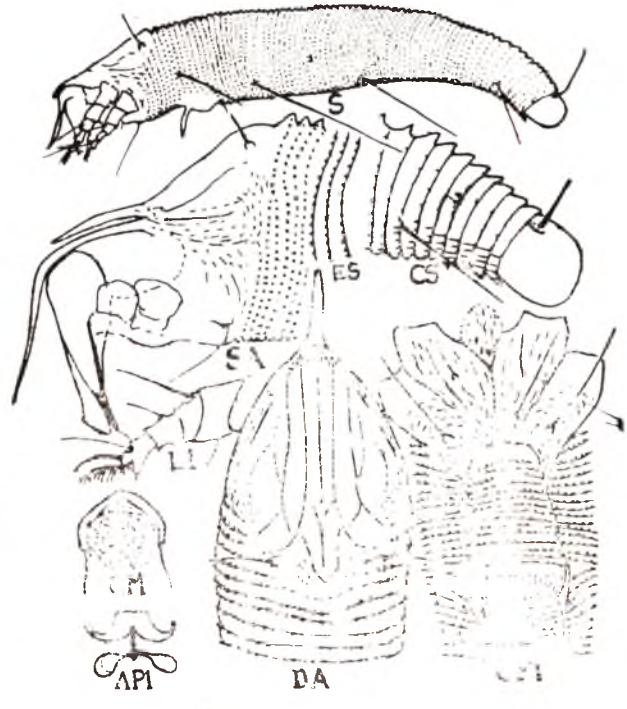

Fig. 4. *Stenarhynchus aristidus* sp. nov.

behind: caudal seta 60 long, accessory seta 3 long. Female genitalia 14 wide, 12 long, genital seta 6 long, coverflap with about 10 lines.

Male: 180 long, 40 thick, genitalia 20 wide, genital seta 4 long.

Types: A **holotype** slide and 4 **paratype** slides, all with ♀♀ and ♂♂, INDIA TAMIL NADU: South Arcot District, Villupuram taluk, Thalavannur, 29. ix. 1980 ex *Cyperus rotundus:* (Cyperaceae), Coll. M. Mohanasundaram, No. 378 (TNAU)

Remarks : The mites are found within the leaf sheath. Among the population gigantic forms of the same species are met with. These individuals are about twice larger than the nomal forms; the shield pattern and the feather claw agree with the type. Thick and thin forms in the population of the same species has been recorded in the case of the sugarcane blister mite *Eriophyes sacharini* (Wang) (Channabasavenna, 1966) and the significance of such variation in a population has been discussed by Mohanasundaram (1981). Hence, the measurements of the gigantic from of *Eriophyes rotundae*, sp. nov. is given below.

Female: 320-350 long, 58 thick, rostrum 17 long, antapical seta 7 long. Shield 40 wide, 38 long, Dorsal tubercles 15 apart dorsal seta 7 long. Foreleg 28 long, tibia 6 long, tibial seta 4 long, tarsus 6 long, claw 6 long; hindleg 27 long, tibia 5 long, tarsus 5 long, claw 8 long. Abdomen with 80-85 rings, uniformly microtuberulate, lateral seta 23 long on ring 11, first ventral seta 25 long on ring 26, second ventral seta 10 long on ring 46, third ventral seta 30 long on ring 6 from behind; caudal seta 85 long, accessory seta 4 long. Female genitalia 20 wide, 15 long, genital seta 10 long, coverflap with 10-12 lines.

2. Eriophyes euphorbiae, sp. nov. (Fig. 2)

This new species resembles *Eriophyes casuarinae* Channabasavanna (1966) in its median and admedians on the shield, and the granular sides of the shield, but differential from it by the submedians on the shield, the forward directing, elongated dorsal setae, the granular coxal area, lesser number of scorings on the female genital coverflap; the 5 rayed feather claw and the spine like dorsal microtubercles.

Female: Worm like, 190-220 long, 60 wide, rosturm 22 long, evenly down curved antapical seta 7 long. Shield with a clear pattern of lines, 40 wide, 27 long, median complete, admedians complete, joined at rear shield margin with the median in a broad shaped joint; first submedian complete, converging anteriorly; second submedian cover anteriorly and forked posteriorly, one arm of the fork joining with first submedian; third submedian broken, forms the border of the shield on the lateral sides, sides of shield with fine scorings. Dorsal tubercles away from shield margin, 23 apart, dorsal setae 20 long pointing forward. Foreleg 25 long, tibia 6 long, tibial seta 4 long at basal 1/3, tarsus 6 long, claw 6 long, feather claw 5 rayed. Hindleg 23 long, tibia 5 long, tarsus 5 long, claw 7 long. Coxae with all three setiferous tubercles. tubercle I and II in line in the forecoxae

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API—Female internal apodeme; CS—Side view of caudal end; DA—Dorsal view of anterior end; ES—Side skin structure; F—Feather claw; GFI—Female genitalia and coxae from below; GM—Genitalia of male; L1—Foreleg; L2—Hind leg; S—Side view of mite; SA—Side view of anterior end.

tubercle III placed wider apart in hind coxae; coxal area granular with a clear sternal line. Abdomen with about 60 uniformly microtuberculate rings, microtubercles triangular spine like; lateral seta 20 long on ring 12, first ventral seta 55 loag on ring 22, second ventral seta 5 long on ring 35; third ventral seta 20 long on ring 5 from behind; caudal seta 40 long, genital seta 10 long, genital seta 10 long, coverflap with 7-8 lines.

Male: 180 long, 55 wide, genitalia 18 wide, genital seta 8 long.

Types: A **holotype** slide with ♀♀ and 5 **paratype** slides with ♀♀ ane ♂♂, INDIA TAMILNADU: Vriddhachalam, 20. viii. 1980, ex *Euphorbia antiquorum* (Euphorbiaceae), Coll. M. M. Mohansundaram, No. 364 (TNAU)

Remarks The mites found in the tender parts, causing rusting.

3. **Eriophyes plectroniae**, sp. nov. (Fig. 3)

This species resembles *Eriophyes canthii* Channabasavanna (1966) in its broad shield and clear coxal area but differentiated from it by the 5 rayed feather claw, smooth female genital coverflap and the sides of shield showing protuberences. Moreover this species is not a gall maker.

Female : 180-200 long, worm like, 50 wide, rostrum 15 long, evenly down curved, antapical seta not visible. Shield 40 wide 25 long, median and admedians represented in the posterior half of the shield, sides of shield with 3 or 4 bulgings on either side; anterior region of shield clear. Dorsal tubercles near rear shield margin, dorsal seta 8 long, pointing upward and forward. Foreleg 20 long, tibia 5 long, tibial seta 3 long at basal 1/3, tarsus 5 long, feather claw 5 rayed. Hindleg 20 long, tibia 4 long tarsus 5 long, claw 7 long. Coxae with all three setiferous tubercles, tubercle I in the anterior margin and tubercle II near basal portion of forecoxae, tubercle III at basal portion of hind coxae; coxal area clear. Abdomen with about 46-48 rings, uniformly microtuberculate, microtubercles elongated, situated at the posterior margin of each ring, last 10 tergites without mictotubercles, the telosomal sternites with microstriations,lateral seta 15 long on ring 8, first ventral seta 60 long on ring 17, second ventral seta 7 long on ring 27, third ventral seta 18 long on ring 4 from behind, caudal seta 40 long, accessory seta absent. Female genitallia 20 wide, 10 long, genital seta 6 long, coverflap smooth, internal apodeme appears shortened.

Male: 170-190 long, 50 wide, genitalia 18 wide, genital seta 5 long, fairly common among the population.

Types: A **holotype** side with ♀♀ and six **paratype** slides with ♂♂ and ♀♀ INDIA: TAMILNADU: Neyveli, 2. viii. 1980 ex *Plectrania parviflora* (Lam) Bedd. (Rubiaceae). Coll. M. M. Mohanasundaram, No. 354 (TNAU).

Remarks: The mites are found as under surface leaf vagrants in the corners of the leaf veins along the mid rib on the lower side.

Stenarynchus gen. nov.

This genus is referable under Rhyncaphytoptinae of the family Rhyncaphytoptidae owing to the presence of a large rostrum abruptly bent vertically downwards, having long form oral stylets and with a simple undivided feather claw. It resembles the genus *Stenecis* Keifer (1970) by its anterior shield lobe projecting oaer the rostrum base and the worm like abdominal structure without tergal sternal differentiated from

Rhyncaphytoptus Keifer (1939) by the uniform abdominal rings; from *Rhynoptus* Liro (1943) by the shape of the body; from *Peralox* Keifer (1962) by the absence of the lateral projections and absence of indentation between shield and first tergite; from *Quadracus* Keifer (1924) by the even shape of the dorsum from *Cheiracus* Keifer (1977) by the simple nonradiating feather claw and the worm like body; from *Asetacus* Keifer (1952) by the presence of the dorsal setae; from *Catarhinus* Keifer (1959) by the absence of the bent apical sensory seta on the rostrum; and from *Hyboderus* Keifer (1975) by the absence of the strong lateral microtubercles. The new genus is also characteristic in its anterior shield lobe projecting over the rostrum which is not present in any other Rhyncaphytoptid genus.

Body elongate worm like, abdomen with narrow rings not differentiated into tergites and sternites; uniformly arched without any projections or troughs. Rostrum large, abruptly bent down with long form oral stylets; shield triangular with a narrow lobe over rostrum base; dorsal shield tubercles just near margin, dorsal setae pointing upwards. Legs with all usual setation, feather claw simple. Coxae with a clear sternal line; all three setiferous tubercles present. Abdomen with all standard setae; female genitalia away from coxal base separated by more than 10 rings, coverflap with longitudinal scorings, internal apodeme normal. Telosome with the cadual seta present and accessory seta absent.

Type species; Stenarhynchus aristidus., sp. nov.

4. Stenarhynchus aristidus sp. nov. (Fig. 4)

Female: Worm like, 250—280 long, 40 wide, rostrum 35 long, abruptly bent vertically downwards antapical seta 3 long. Shield 30 wide, 30 long, apical projection over rostrum 10 long. Median line broken in the anterior half, forked towards posterior half, admedians complete, forked at the posterior end, second submedian complete, short and joins with the first submedian at the posterior end, third submedian broken and curved, represented in the basal half of the shield with fine scorings. Dorsal tubercles at rear shield margin, 10 apart, dorsal seta 15 long, pointing upwards. Foreleg 20 long, tibia 6 long, tibial seta 6 long, tarsus 6 long, claw 7 long, featherclaw 10 rayed. Hindleg 25 long, tibia 6 long, tarsus 5 long, claw 8 long. Both legs with the usual setation. Coxae closely approximated with a clear sternal line, all three setiferous tubercles present, coxal area with thick lines. Abdomon with about 78 rings, uniformly tuberculate without tergal-sternal differentiation, lateral seta 20 long on ring 10; first ventral seta 80 long on ring 24, second ventral seta 50 long on ring 42, third ventral seta 22 long on ring 10 from behind, caudal seta 50 long, accessory seta dot like. Female genitalia 22 wide, 17 long, genital seta 15 long, coverflap with about 16 lines.

Male: 230-250 long, 35 wide, genitalia 14 wide, genital seta 12 long.

Types: A **holotype** slide with ♀♀ and 5 **paratype** slides with ♀♀ and ♂♂. INDIA: TAMIL NADU, Vriddhachalam, Regional Research Station, 10.x.1980. ex *Aristida setacea* Retz (Poaceae) Coll. M. Mohanasundaram, No, 390 (TNAU). The mites are found on the upper surface of the leaf in the laminal grooves.

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Entomon, 1983, *Vol.* 8, *No.* 3, *pp.* 269 *to* 275

RNA METABOLISM IN THE SALIVARY GLANDS OF *DYSDERCUS KOENIGII* (HETEROPTERA, PYRRHOCORIDAE): AUTORADIOGRAPHIC AND ELECTROPHORETIC INVESTIGATIONS

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The origin and fate of RNA in salivary glands of the bug *Dysdercus koenigii* was studied by autoradiography and electrophoresis. Mitoses do not occur in the glands of adult insects, but the nuclei of the glandular epithelial cells increase in size by polyploid growth or by specific gene amplification, as evidenced by the asynchronous incorporation of ^{3}H-thymidine. Experiments with ^{3}H-uridine showed that the gland cell nuclei are the main sites of RNA synthesis. Part of this RNA may be mRNA that could serve in the synthesis of proteins in the gland cell cytoplasm. But most of the nucleolar RNA moves into the cytoplasm from where it is exported into the lumen. With increased incubation time, the RNA tends to accumulate in the lumen without any perceptible turnover. The nucleolar origin of this lumen RNA and its stable character suggests its ribosomal nature. The electrophoretic result confirms the presence of RNA in the gland lumen, which might remain conjugated with the protein in the form of RNP.

(*Key words*: RNA metabolism, salivary glands, *Dysdercus koenigii*)

INTRODUCTION

Salivary glands of the Hemiptera are known to produce a variety of proteins and enzymes used both for piercing and sucking as well as for digesting the food materials (see review by MILES, 1972). Some of the salivary secretions may be used for the formation of a protective sheath in which the mandibular and maxillary stylets move (SAXENA, 1963). In the Hemipterous species investigated so far, conjugated carbohydrate and phospholipid may also be present (MILES, 1964). In *Dysdercus koenigii* the sheath material is mainly composed of ribonucleoprotein (RNP) (KUMAR *et al.*, 1978). Most of the salivary secretions are synthesised by the glandular epithelial cells, although immunological and tracer studies have demonstrated that exogenous materials transported from the haemolymph also could contribute to the formation of salivary secretions (KUMAR *et al.*, 1978; LAUFER & NAKASE, 1965; MILES, 1967).

Synthetically active cells produce large amounts of different species of RNA that are involved in the synthesis of proteins and enzymes (see review by GOLDSTEIN, 1965). RNA metabolism in salivary glands of insects is little understood, though this subject was repeatedly investigated in the polytrophic insect ovaries (BIER, 1963; RAMAMURTY, 1963; see also review by TELFER, 1965). Our histochemical studies on salivary glands of *Dysdercus* showed considerable amount of RNA not only in the gland cell cytoplasm but also in the lumen. The present

autoradiographic and electrophoretic studies were undertaken to elucidate the origin and fate of this RNA.

MATERIALS AND METHOD

Salivary glands of adult insects *Dysdercus koenigii* reared in the laboratory were used in this study. For the histochemical localization of DNA and RNA, paraffin sections of the glands were stained with Feulgen, toluidine blue, gallocyanine and methyl green pyronin-Y. ^{3}H-thymidine (sp. activity: 5.4 Ci/mM, dosage 5μg/0.05 ml) was injected as a tracer to study the polyploid growth of the glnnd cell nuclei. To investigate the RNA metabolism, the insects were injected with ^{3}H-uridine (sp. activity: 2.8 Ci/mM, dosage: 5μg/0.05 ml) and incubated for 15 min, 30 min, 1h, 2h, 8h and 12h. At the end of the incubation periods, salivary glands were dissected out and fixed in Carnoy's fluid. Paraffin sections processed for autoradiography, using Kodak AR-10 stripping film. Exposure time varied from 2 to 4 weeks. Appropriate RNAse controls for the autoradiographs were maintained.

For electrophoresis, the saliva from the ruptured (10 pairs) salivary glands was dissolved in 0.2 ml of the sample buffer (0.02 ml 0.1M PO_4 buffer, pH 7.5 and 0.18 ml 1% SDS and 1% 2-mercaptoethanol). The disc gel electrophoresis was performed according to the method of DAVIS (1964). The saliva was centrifuged at 10,C00 rpm for 15 min. The supernatent was treated at 100°C in water bath for 3 min. 0.1 ml of the sample was loaded on 7.5% acrylamide gel containing 0.2% SDS. The gel was run in 0.1 M tris-glycine buffer, pH 8.5 containing 0.1% SDS. Electrophoresis was conducted at a current of 3 mA/tube with a running time of 2h. After the electrophoretic run, the gel was fixed in 50% TCA overnight at 4°C, and thereafter the gel was stained with 0.1% acridine orange (a specific stain for RNA) in 15% glacial acetic acid for 30 min at room temperature. The destaining was done in distilled water and the gel was preserved in 7% glacial acetic acid.

RESULT

The principal salivary gland of this insect consists of a pair of irregularly shaped disc-like structure situated on either side of the oesophagus. Each gland is associated with a long, tubular and highly coiled accessory gland. Histologically, the walls of the principal salivary gland are made up of the following structures from outside inwards: 1. two peritoneal layers composed of squamous cells; 2. a basement membrane on which rest 3. the glandular epithelial cells of columnar or cubical shape, bearing large polyploid branched nuclei and 4. a spacious lumen containing salivary secretions (KUMAR, 1982). The following account relates to the principal gland.

In histological preparations, mitotic divisions were not noticed in the gland cells of adult insects. With Feulgen technique, the nuclei of the glandular epithelial cells react with highly varied intensities, indicating their varied DNA content. This is suggestive of their endopolyploid growth and was confirmed by the autoradiographs. 90 min incubation with ^{3}H-thymidine showed in the autoradiographs an asynchronous incorporation of the label with different intensities in some of the gland cell nuclei which are in the replicative phase of their endopolyploid growth, while the other nuclei which are not in the S-phase of the cell cycle do not incorporate the label at all (Fig. 1).

The glandular epithelium lining the lumen, gives a strongly basophilic reaction with toluidine blue and gallocyanine. In the methyl-green-pyronin Y stained preparations, only the cytoplasm and the multiple nucleoli show pyroninophilia, while the chromatin is stainable with a greenish tinge. The lumen contents also reveal a strong pyroninophilia which is RNAse sensitive indicating their RNA nature.

In the autoradiographs, 15 min incubation with ^{3}H-uridine produces a

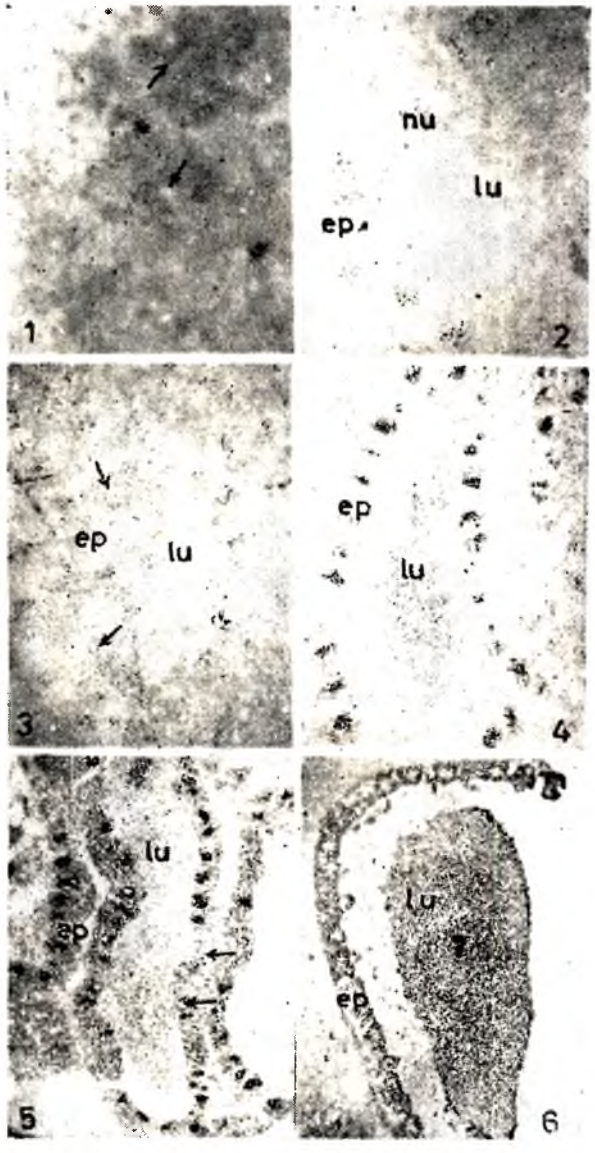

FIG.7

Fig. 1. An autoradiograph of the salivary gland incubated for 90 min with ^{3}H-thymidine showing an asynchronous incorporation of the label in the nuclei which are in the S-phase of the cell cycle. Others which are not in the S-phase do not incorporate the label at all (→). ×280. Figs. 2 6. Autoradiographs of the salivary gland's lobule incubated for different periods with ^{3}H uridine, showing the activity patterns in the nuclei (n) of the glandular epithelium (ep) and the lumen (lu). Fig. 2. Incubation time 15 min. Incorporation of the label can be seen exclusively in the gland cell nuclei. Lumen is not labelled. × 280. Fig. 3. Incubation period 30 min. Radioactivity moves into the cytoplasm towards the lumen (→). The label begins to appear in the lumen. × 280. Fig. 4. Incubation time 2h. Note the general intensification of the incorporation pattern in the nuclei, cytoplasm and the lumen×280. Fig. 5. Incubation time 8h. The nuclei show the heaviest labelling. Some of the nuclei (→) already seem to be partially empty. The cytoplasm shows an intermediate level of labelling while the lumen contents show relatively the lowest degree of labelling. × 230. Fig. 6. Incubation time 12h. Most of the gland cell nuclei appear to be empty, while the cytoplasm and the lumen contents show the degree of heavy labelling. ×230. Fig. 7. SDS disc gel electropherogram of saliva from adult *Dysdercus koenigii*. The band (—) shows the possible RNA in the gland lumen. Electropheroesis was performed in 7.5% acrylamide in the presence of 0.2%SDS at PH 8.5 and the RNA was stained with acricdine orange; gel diameter 6 mm.

labelling that is restricted to the gland cell nuclei, wherein the activity seems to be confined mostly to the multiple nucleoli. With this short incubation period, neither the cytoplasmic areas of the gland cells nor the lumen contents show any radioactivity which is higher than that of the background (Fig. 2). 30 min incubation revealed the movement of the radioactivity from the nuclei into the cytoplasm in the direction of the lumen (Fig. 3). The lumen contents also begin to show the incorporation of the label to a moderate degree. When the incubation period was extended to 2h, the activity pattern showed a general intensification in the gland cell nuclei, cytoplasm and the lumen contents. Now a diffuse labelling is noticeable in the entire cytoplasmic space (Fig. 4). With an incubation for 8h the labelling pattern undergoes a further intensification. The gland cell nuclei now show the highest radioactivity while the cytoplasm shows an intermediary level of labelling. Already some of the gland cell nuclei here and there appear empty, as the pool of labelled molecules become exhausted (Fig. 5). This feature still becomes more clearly manifest in the autoradiographs with 12h incubation. With this long incubation, most of the gland cell nuclei are not labelled any more, whereas the cytoplasm and the lumen contents exhibit the heaviest labelling (Fig. 6).

With all the incubation times described above the radioactivity of the gland cell nuclei, cytoplasm and lumen can be abolished by pretreating the sections with 0.1% RNAse at 30°C. Also the basophillia observed in these sites could be abolished with RNAse. The polyacrylamide gel electrophoresis reveals that there is a single feeble band of RNA at the extreme positive end of the gel. Since RNA is negatively charged the band is close to the positive end of the gel (Fig. 7).

DISCUSSION

Since no mitoses occur in the glandular epithelial cells of adult insects, the asynchronous incorporation of ^{3}H-thymidine observed in some of the nuclei is suggestive of their DNA replication that is probably related to their polyploid growth. This is a phenomenon which is well documentad for the trophocyte nuclei of polytrophic ovaries of insects (COLOMBO, 1955; RAMAMURTY, 1965), as well as in the labial glands of the silk moth *Antheraea polyphemus* (SELMAN & KAFATOS, 1974). In all these cases the polyploid growth of the nuclei would seem to precede the RNA synthesising function of the cells. However, the ^{3}H-thymidine incorporation in some of the gland cell nuclei seen here, might as well be an expression of repair DNA synthesis or specific gene amplification, as it was impressively demonstrated in the germinal vesicle of insect oocytes (BIER *et al.*, 1967; MATAUSZESKI & HOSER, 1974).

The specificity of ^{3}H-uridine in selective labelling of RNA in the salivary glands of insects was shown by (SIRLIN & JACOB, 1964; JACOB, 1967). The results of the present study with ^{3}H-uridine show that the main sites of RNA synthesis are the salivary gland cell nuclei, especially their multiple nucleoli. With increasing incubation time, the radioactivity is seen to move into the cytoplasm and then eventually into the lumen of the glandular lobules. No clear vesicle formation is detectable at the epithelial border facing the lumen, indicating that the labelled molecules move into the lumen perhaps by a process of diffusion along a concentration gradient. The progressive accumulation of the label in the lumen suggests

that the destination of most of the molecular RNA is the lumen, wherein it conjugates with protein.

The site of synthesis of RNA and its transport into the salivary gland lumen shows a parallel to the processes described in the trophocytes of the polytrophic ovaries of *Drosophila* (King & BURNETT, 1959; ZALOKAR, 1960), *Musca* (BIER, 1963) and *Panorpa* (RAMAMURTY, 1963). Here both mRNA and rRNA may be produced in the gland cell nuclei but a major part of it would seem to be rRNA, since it appears to be of nucleolar origin and shows no signs of turnover, as revealed by its progressive accumulation in the glandular lumen. The electrophoretic study results in the presence of RNA in the glandular lumen, thereby confirming the above observation.

Our histochemical analyses of the lumen contents showed that they are made up predominantly of RNP, besides glycoproteins, free glycogen, neutral lipids and a variety of proteins and enzymes, especially proteases and peroxidases (KUMAR *et al.*, 1978). It is possible that the RNA reaching the lumen may conjugate with the protein to produce the RNP which might be used as the protective sheath material around the mandibular and maxillary stylets at the time of piercing and feeding (SAXENA, 1963; MILES, 1964).

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HISTOPATHOLOGICAL EFFECTS OF X-IRRADIATION ON THE OVARIES OF THE RED COTTON BUG. *DYSDERCUS KOENIGII* FABR. (HETEROPTERA : PYRRHOCORIDAE)

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X-irradiation effects on the ovaries of *Dysdercus koenigii* have been studied during longer part of the postirradiation period. The energy affects both somatic and germinal cells. First to show radiation injury are the somatic binucleate trophocytes in the germarium which undergo complete cytolysis to leave nuclear aggregates named as the coenocytic masses, This is followed by certain precocious changes in the oogonia and later by fusion between oocytes in the vitellarium due possibly to the loss or displacement of the barriers of the interfollicular tissue and follicular epithelium. The radiation-damaged oocytes are lost by two different mechanisms : by resorption involving vitellophagic activity of the follicular epithelium and by enzymatic dissolution without this activity. The follicular epithelia of the resorbing and dissolving oocytes exhibit variable responses to radiation : the former undergoing hypertrophy and the latter, hyperplasia. The ovaries get fully dystrophied by 26th day postirradiation.

(*Key words:* histopathological effects, X-irradiation, ovaries, *Dysdercus koenigii*)

INTRODUCTION

While a fair amount of work has been done on the effects of ionizing radiations on polytrophic ovaries of insects (see THEUNISSEN, 1977 for references), only a few studies have been made on telotrophic ovaries. These studies either compare the effects of radiation with those of chemosterilants (AMERESEKERE *et al.*, 1971; BEAVERS *et al.*, 1971) or assess the effects of different doses of radiations (MOCHIDA, 1973). Both kinds of studies have, however, restricted their observations to the early part of the insect's life cycle. Since radiation injury enhances with passage of time, it will be more instructive to follow histological events leading to ovarian dysfunction at short intervals spreading over greater part of the postirradiation period. The knowledge gained from such a study could be useful in sterile insect technique of insect pest control whose success depends entirely upon the radiation induced sterility. In this paper we present the results of such a study on the telotrophic ovaries of the hemipteran, *Dysdercus koenigii*, a pest of several important malvaceous plants in this country.

MATERIALS AND METHODS

One day old 5th (ultimate instar) female larvae of *D. koenigii* were exposed to a predetermined sterilizing dose of 2000 rad of soft X-rays (Picker Inc. Ltd., USA, with 1 mm aluminium filter), at a dose rate of 444.44 rad/min (110 kv, 4.5 mAmp, 10 cm distance). The emerging adults were sacrificed on days 1,3,5,10,15 and 20. The ovaries were removed in insect Ringer (EPHRUSSI & BEADLE, 1936), fixed in Bouin's fluid, processed, sectioned at 7.5 μm and stained routinely in haematoxylin and eosin for histological observations.

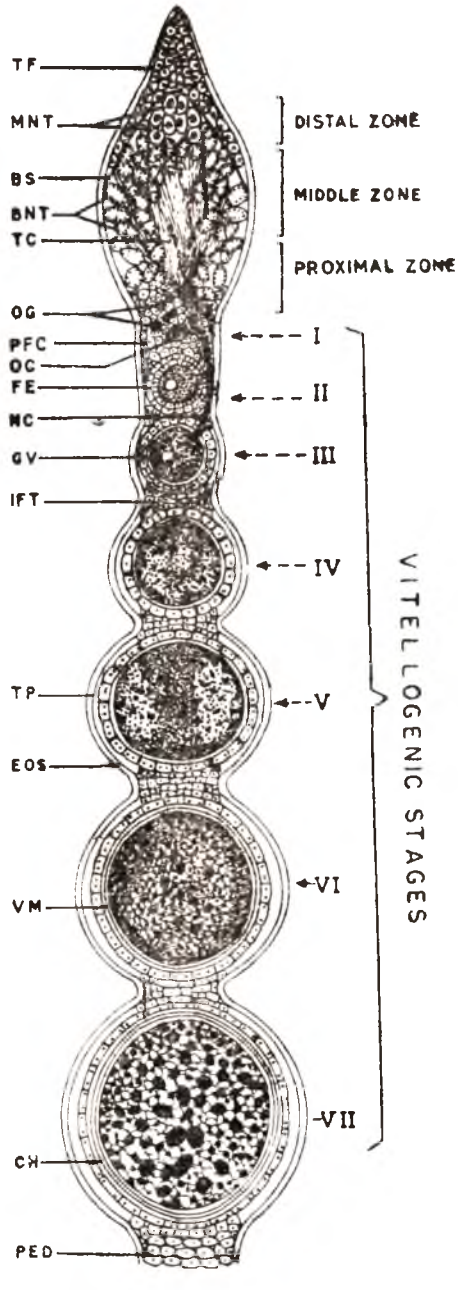


Fig. 1. Schematic diagram of an ovariole showing its normal strcture and stages in the cocyte maturation.

OBSERVATIONS

Gross histology of the ovaries

The ovaries of *D. koenigii* comprise 7 ovarioles each divisible into a terminal filament, germarium, vitellarium and pedicel, all enclosed in two sheaths: an outer, the external ovariole sheath and an inner, tunica propria (Fig. 1). The terminal filament is made up of smal rounded cells. The germarium is divisible into proximal, middle and distal zones. The proximal zone contains oogonia, prefollicular cells (PFC) and binucleate trophocytes (BNT), the middle zone, BNT and mononucleate trophocytes and the distal zone, only the latter. A hyaline trophic core intervenes the BNT in the proximal and middle zones which is connected to the oocytes through nutritive cords. The oogonia are small spherical cells measuring $12.3 \pm 3.17 \times 9.6 \pm 1.16$ μm. The vitellarium contains 9—12 oocytes surrounded by follicular epithelium (FE) and separated by interfollicular tissue (IFT). The maturation of the oocytes is divisible into 7 developmental stages (for details, see DESHPANDE & SRIVASTAVA, 1981).

Histopathology of the ovaries

The effects of X-irradiation first show up in the proximal zone of the germarium, then ascend to the middle zone and finally to the distal zone and magnify in time. The following description gives histopathological changes that occur in the ovarioles of the X-irradiated adults on days 1, 3, 5, 10, 15 and 20 postemergence.

In 1 day old adult (7 days postirradiation or p. i.), the first to be affected are the inner BNT lying nearer the trophic core. They lose thier compact arrangement by developing spaces and develop pathological symptoms like pycnosis,

karyorrhexis (= break down of nuclei) and in a few cases, lysis in the cytoplasm (Fig. 2). The number of oogonia in the germarium and of oocytes in the vitellarium is appreciably reduced—only 2-5 of them can be seen per section compared to 9-12 in normal ovarioles.

On day 3 (9 days p. i.), more BNT turn pathological developing additional symptoms like cellular and nuclear hypertrophy (= hyperchromatosis, Fig. 3). Cytolysis started earlier spreads to more BNT liberating their nuclei which collectively form coenocytic masses. Some of the coenocytic nuclei tend to degenerate by karyolysis. A few oogonia enlarge ($145.8 \pm 11.86 \times 112.2 \pm 9.11 \mu m$) to block the vitellarial neck and the number of PFC gets appreciably reduced (Fig.4) so that some of the oocytes reaching vitellarium are left partly uncovered and tend to fuse (Fig.5). Vitellogenesis that commences in the oocytes of normal adults on day 3 postemergence has not yet started.

On day 5 (11 days p. i.), the pathological symptoms reach the middle zone of the germarium. More coenocytic masses are produced which encroach and reduce the trophic core region (Fig. 6). Hypertrophied oogonia show occasional fusion and connections with the trophic core through very short nutritive cords. In the vitellarium, some of the lower (older) oocytes lose their normal linear orientation and tend to become lateral. In doing so they seem to squeeze the IFT and FE out (Fig. 7) and tend to fuse partially (Fig. 8) or completely (Fig. 9). Vitellogenesis which is completed by this time in normal insects is clearly partial.

In 10 days old adult (16 days p. i.), the pathological symptoms ascend to the distal zone of the germarium. The middle and proximal zones by now get filled with coenocytic masses, cellular debris and a few normal and hypertrophied oogonia (Fig. 10). In some of the ovarioles, the oogonia fail to descend into the vitellarium possibly due to blockage of the vitellarial neck as seen earlier (Fig. 4), so that they remain empty, tubular and shrunken (Fig. 11). In other ovarioles, the oocytes show central (Fig. 11) or peripheral (Fig. 12) vacuolisation in their cytoplasm. In such oocytes, yolk spheres are lacking in the vacuolised areas. Fusion between several oocytes may occasionally result in a multinucleate (compound) follicle (Fig. 13). The growth of the vitellogenic oocytes is retarded; it does not go beyond stage IV (out of the VII maturation stages (DESHPANDE & SRIVASTAVA, 1981) and resorption sets in. The cells of the FE enlarge, give out resorption bodies at their tips (Fig. 14) and penetrate the oocyte periplasma to cause resorption leaving a yellowish debris (Fig. 15 A). The IFT show hyperplasia (= increase in cell number) in some cases (Fig. 15A) and hypoplasia (= decrease in cell number) in others (Fig. 15 B).

Abbreviations to Fig. 1

ENT—binucleate trophocytes; BS—basal septum; CH—chorion; EOS—external ovariole sheath; FE—follicular epithelium; GV—germinal vesicle; IFT—interfollicular tissue; MNT—mononucleate trophocytes; NC—nutritive cord; OC—oocyte; OG—oogonia; PED—pedicel PFC—prefollicular cells; TC—trophic core; TF—terminal filament; TP—tunica propria; VM—Vitellarium.

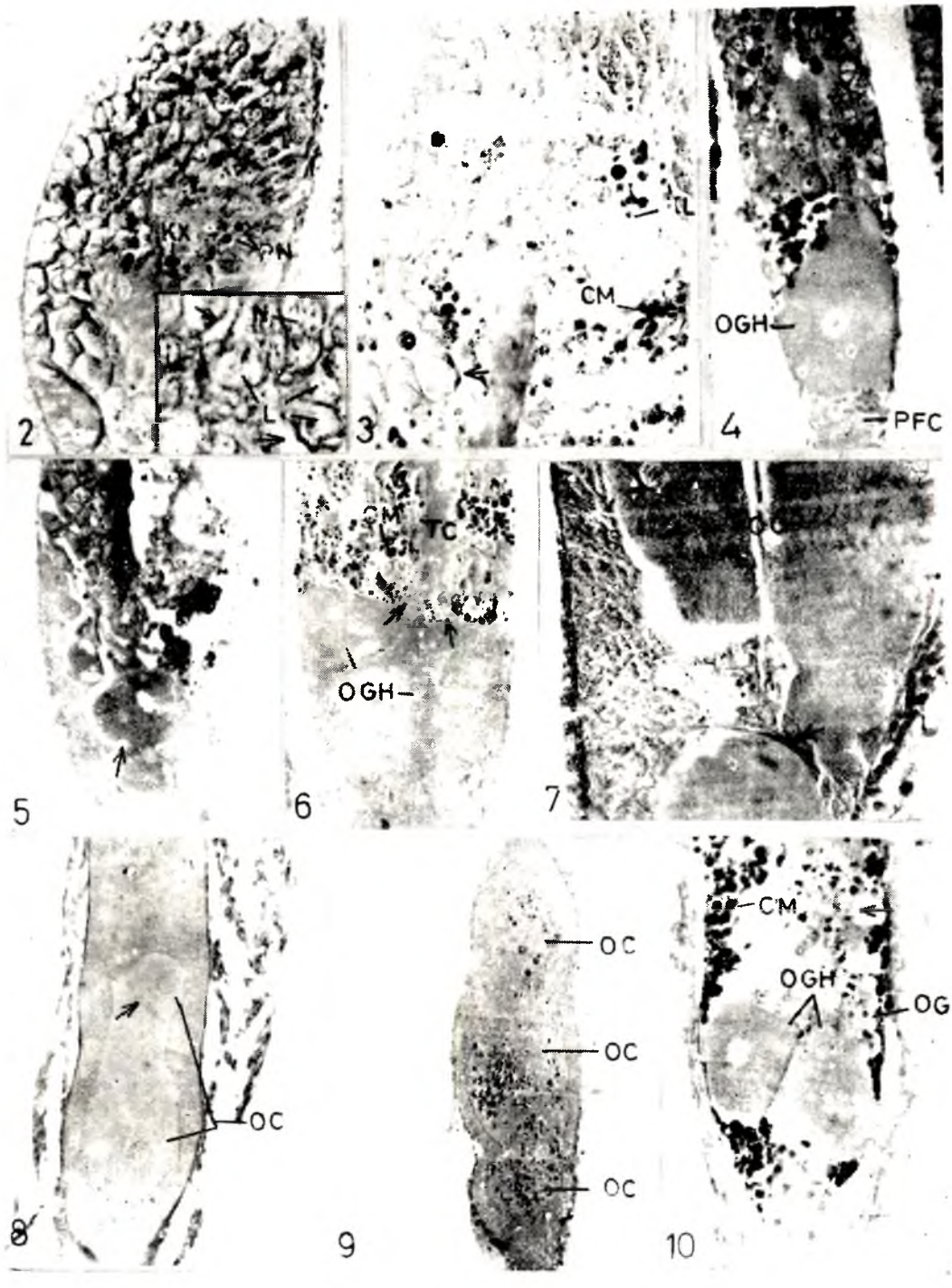
On day 15 (21 days p.i,), the germarium is filled with coenocytic masses, cellular debris and a few normal and fused oogonia (Fig. 16). The PFC degenerate and the germarial contents flow into the vitellarium (Fig. 17). Non-vitellogenic oocytes undergo enzymatic dissolution in which FE does not participate (Fig. 18). The FE of such oocytes become hyperplasic (Fig. 18) to the extent of encroaching and filling the vitellarial lumen in absence of oocytes (Fig. 19). The FE of the resorbing oocytes on the other hand, undergo vacuolisation to appear as a spongy tissue (Fig. 20).

On day 20 (26 days p. i), the radiation damage reaches its peak, the ovaries becoming dystrophic with their ovarioles full of unidentifiable cellular debris (Fig. 21).

DISCUSSION

Two conclusions at once emerge from the above studies *viz.*, X-irradiation injury is a continuing phenomenon whose final quantum is known only many days after the exposure and the somatic cells, the BNT, showing the first pathological symptoms, are the most radiosensitive cells in the female of this insect unlike the sex cells in the male (our unpublished observations), Radiosensitivity has been shown to be directly related to the physiological activity of the cells (BERGONIE & TRIBONDEAU, 1906; HABER & ROTHSTEIN, 1969). Therefore, the possible explanation for the second of the above phenomena could be an elevated physiology of the BNT necessary to sustain the previtellogenic oocytes by synthesising and supplying substances like RNA (BONHAG, 1955; BIER, 1969; CHOI & NAGL, 1976, 1977a) and RNP (ribonucleoprotein, CHOI & NAGL, 1976, 1977). A maximal trophocyte activity associated with these processes has indeed been shown in the 5th (ultimate) instar larva of another hemipteran (CHOI & NAGL, 1977b). The occurrence of the trophocyte derived coenocytic masses in the vitellarium as observed in this insect, has not been reported earlier. Peristaltic contractions which normally occur in the ovarioles might be driving these germarial contents down the vitellarium due to reduced obstruction by the loss of tissues like PFC, IFT, FE and oocytes. Ionizing radiations are known to produce 3 other effects in insect tissues: inhibit mitosis (KING, 1967), retard development

Fig. 2. Germarium showing pycnosis (PN) and karyorrhexis (KX) in the BNT, loosening of BNT as indicated by appearance of spaces (arrows, inset) and lysis (L, inset) in the cytoplasm (Cf., N, normal cells). Adult 1 day old (7 days p.i).×150; inset×450. Fig. 3. Germarium with BNT (arrow) showing hypertrophy and hyperchromatosis and coenocytic nuclear masses (CM) with a few nuclei undergoing karyolysis (KL). Adult 3 days old (9 days p. i) × 150. Fig. 4. Germarium showing hypertrophied oogonia (OGH) blocking the vitellarial neck and numerically reduced PFC. Adult 3 davs old (9 ddys p. i.). × 315. Fig. 5. Vitellarium showing fusion betweeen oocytes (arrow). Adult 3 days old (9 days p. i) × 150. Fig. 6. Germarium showing abundance of coenocytic masses (CM), fused hypertrophied oogonia (OGH) and their connections with trophic cord (TC) through short nutritive cords (arrows). Adult 5 days old (11 days p.i.) × 315. Fig. 7. Lateral orientation of oocytes (OC) and displacement of the intervening IFT and FE. Adult 5 days old (11 days p.i.) × 315. Figs. 8,9. Partially (arrow, Fig. 8) and completely fused oocytes (OC) (Fig. 9) with partial vitellogenesis. Adult 5 days old (11 days p. i) × 315. Fig. 10. Germarium filled with coenocytic masses (CM), cellular debris (arrows), few normal (OG) and hypertrophied oogonia (OGH). Adult 10 days old (16 days p.i) × 315.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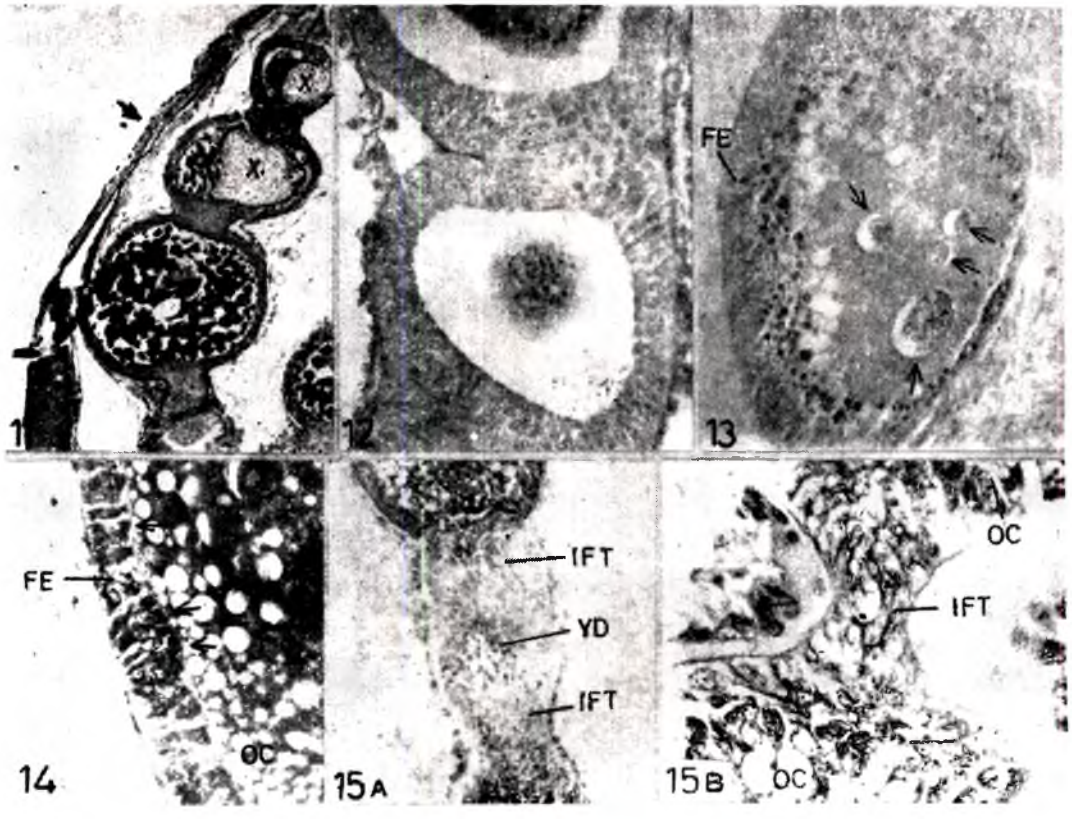
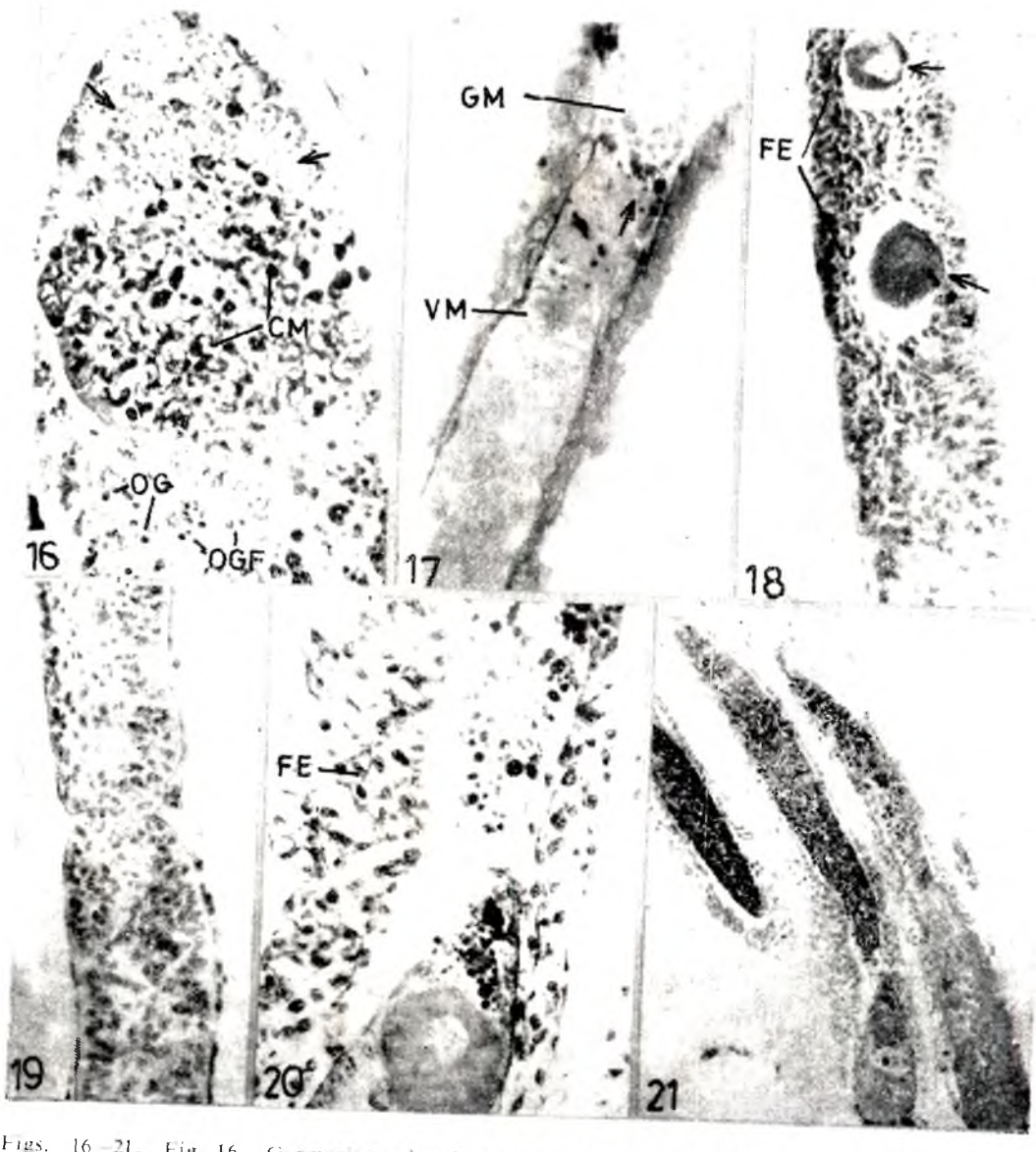


Figs. 11—15. 11. Two ovarioles : one tubular and shrunken (arrow) and the other with oocytes lacking yolk in centrally vacuolised areas (X). Adult 10 days old (16 days p. i.) × 70. Fig. 12. Peripherally vacuolised oocyte. Adult 10 days old (16 days p. i.) × 150. Fig. 13. A compound follicle with 4 nuclei (arrows) in a single sheath of FE. Adult 10 days old (16 days p.i.) × 315. Fig. 14 Enlarged FE cells with resorption bodies (arrows) invading oocyte periplasma (OC). Adult 10 days old (16 days p. i.) × 450. Fig. 15 Vitellarium showing yellowish debris (YD), hyperplasic (Fig. 15A) and hypoplasic (Fig. 15B) IFT. Adult 10 days old (16 days p.i.) A × 150; B × 450.



Figs. 16–21. Fig. 16. Germarium showing coenocytic masses (CM), cellular debris (arrows), a few normal (OG) and fused oogonia (OGF). Adult 15 days old (21 days p. i.) × 150. Fig. 17. Part of the ovariole showing flow (arrow) of the contents of the germarium (GM) into the vitellarium (VM). Adult 15 days old (21 days p. i.) × 150. Fig. 18. Vitellarium showing dissolving oocytes (arrows) and hyperplasic FE. Adult 15 days old (21 days p. i.) × 150. Fig. 19. Vitellarium devoid of oocytes and filled with hyperplasic cells of the FE. Adult 15 days old (21 days p. i.) × 150. Fig. 20. FE appearing spongy. Adult 15 days old (21 days p. i.) × 315. Fig. 21. Dystrophied ovary with unidentifiable cellular debris. Adult 20 days old (25 days p. i.) × 70.

(MOCHIDA, 1973) and induce precocious differentiation in cells (CREIGHTON & EVANS, 1941). All these effects can be seen in the present insect—fewer oogonia and oocytes indicating the first effect, inability of the vitellogenic oocytes to grow beyond stage IV, the second one and an enlarged (hypertrophied) size of the oogonia accompanied by acquisition of nutritive cords while still inside the germarium, the third one. Fusion between the occytes as a result of ionizing radiations as reported by THEUNISSEN (1977) is also encountered in the present insect. This phenomenon has been discussed elsewhere (SRIVASTAVA & DESHPANDE, 1982).

Two modes of oocyte loss are reported in literature : by enzymatic dissolution (THEUNISSEN, 1977) and by resorption (LUSIS 1966; DAVIES & KING, 1972; SAHAI, 1980). In the former, the oocyte dissolves by its own enzymes and in the latter, by the vitellophagic action of the the FE. Since in the present insect, resorption is seen to occur in the vitellogenic and dissolution in the non-vitellogenic oocytes, we are inclined to implicate the presence or absence of yolk as a causative factor in these phenomena. The same reason can be attributed to the variable radiation responses shown by the FE enveloping the resorbing and dissolving oocytes. These largely speculative conclusions, however, need to be put on a firmer ground by further more specific research.

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Entomon, 1983, *Vol.* 8. *No.* 3, *pp.* 287 *to* 291

A NOTE ON THE BIOLOGY OF LEAF MINER *PHYTOMYZA HORTICOLA* GOUREAU ON OPIUM POPPY

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(Received 13 November 1982)

Biology of leaf miner, *Phytomyza horticola* Goureau was studied on opium, *Papaver somniferum* L. under field conditions at Lucknow, India. The larval period, pupal period, and total life duration from egg to adult emergence were observed to average 3, 4 and 9 days, respectively. A deep fringed leaf strain was found more susceptible to this pest than smooth leaf strains of opium poppy.

(*Key words:* Biology, leaf miner, *Phytomyza horticola* Goureau, polythene, infestation, deep fringed leaf strain, smooth leaf strain)

INTRODUCTION

The leaf miner, *Phytomyza horticola* Goureau (Diptera : Agromyzidae) has been recorded to occur throughout the world as a polyphagous dipterous pest. Though sporadic in nature, it sometimes assumes epidemic proportion to cause serious damage to crops. This insect has been recorded as a pest of pea, linseed, potato, sunflower, lettuce, beans and other wild plants (ATWAL, 1976; SETHI *et al.*, 1978). Its occurrence has been reported on opium poppy from Yugoslavia (ANCEV & POSTOLOVSKI, 1978). The biology of this insect as a pest of pea has been studied in India (AHMAD & GUPTA, 1941; ATWAL *et al.*, 1969) but no reference is available on its biology on opium poppy which is an important medicinal plant. The present contribution, therefore, reports ts biology on opium poppy at Luknow in central Uttar Pradesh.

MATERIAL AND METHODS

The infested leaves of opium bearing pupae of leaf miner were brought to the laboratory and further rearing was done at $25 \pm 1^{\circ}C$ and 57 ± 5 per cent relative humidity. The pupae were kept in glass jars covered with muslin cloth for the emergence of flies. Male and female flies were separated out on the basis of genital aperture.

One pair of flies were then kept in one small glass vial and mouth of the vial covered with cotton swab. Glucose solution (20%) in cotton swab was provided as food for adults.

Single healthy leaf was selected from four month leaf strains. Selected leaves were covered with polythene bag size (30×53 cm) in field condition. Five plants of opium poppy were taken for the study. One pair of flies (one male and one female were released in each polythene bag. After two days, the marked leaves were freed from bag and were examined daily carefully for detailed observations on developmental stages till emergence of the adult The data on incidence of leaf miner were recorded by counting the number of mines of leaf lamina in smooth leaf strains and deep fringed leaf strains of opium poppy. Relevant data are given in Table 1, for the damage.

The observations on meteorological data is presented in Fig. 1.

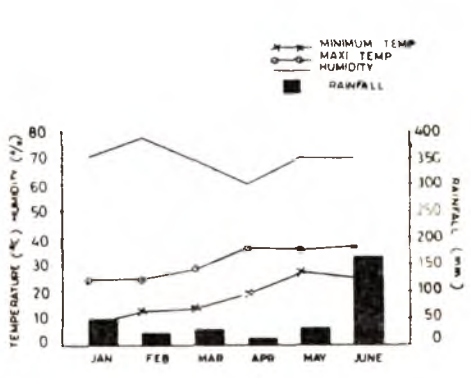


Fig. 1. Meteorogical data during the study of leaf miner.

RESULT AND DISCUSSION

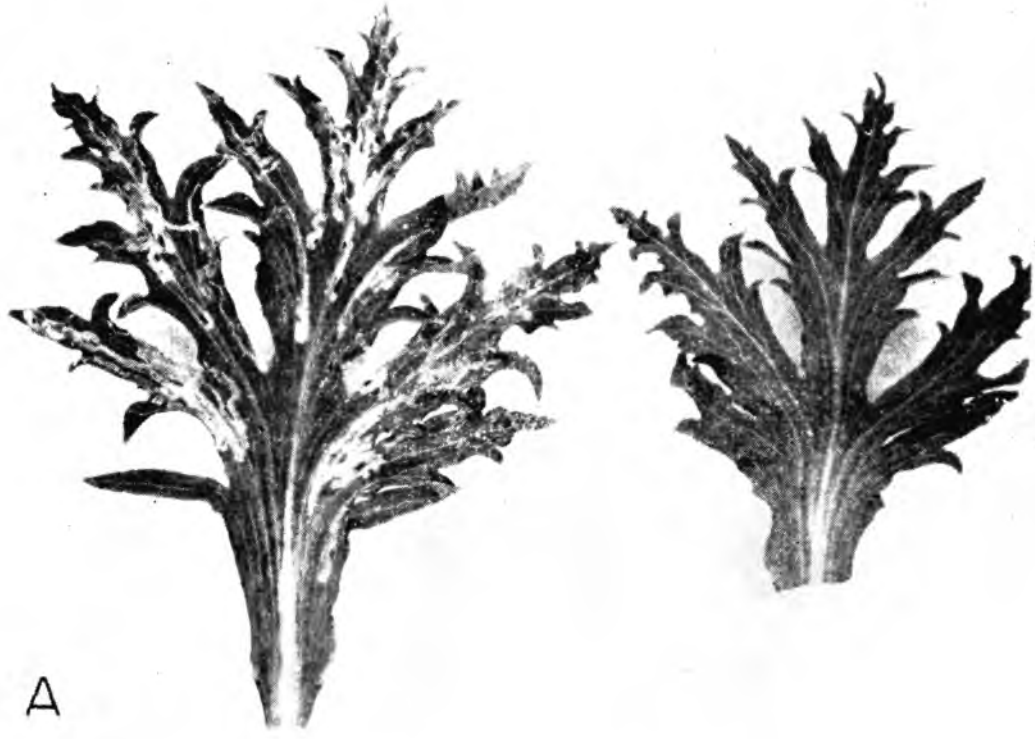
Eggs were laid two days after the release of flies in polythene bags in leaf tissue. The presence of egg was confirmed on the basis of initial mine made by newly hatched larva. Eggs were laid mostly near the margin of the leaf lamina of opium poppy. It was confirmed by the direction of mines made by larva. Mines started from margin of leaves and ended towards mid rib. Newly hatched maggots were creamy white coloured and recently started mining the leaves between upper and lower epidermis by making zig-zag tunnels. The tunnels were fixed with blackish colour excreta of maggot. In the beginning, the width of tunnel was narrow but progressively becomes wider with the increase in the size of the maggot. The damage gave a papery appearance to the leaves and therefore affected the photosynthetic activity in plants thereby reducing its vigour due to non-availability of more photosynthetic area. Maggots were slender and truncated posteriorly. The mouth parts were strong showing dark coloured sclerotisation. Ten larvae were taken for observation and it was found that average larval period on opium poppy was 3 days, and the prepupal period lasted for two days. Pupa was yellowish in colour in the beginning. Later on, its colour changed to dark brown and exhibited well defined segmentation. Pupation took place at the end of mines generally near mid rib after the maggot had cut an emergence hole on the ventral side of the leaf. Pupal period was of 4 days on an average of ten pupae. The adult female bears a pointed abdominal tip, while the male fly has a blunt one. Male was smaller than female in size. Body colour was black and abdomen grey in both male and female flies. Adult male measured average 1.5 mm (n = 5) from head to the tip of the abdomen, while the adult female 2.00 mm (n = 5). The average developmental period from larva to adult emergence was found to be 9 days (n = 10).

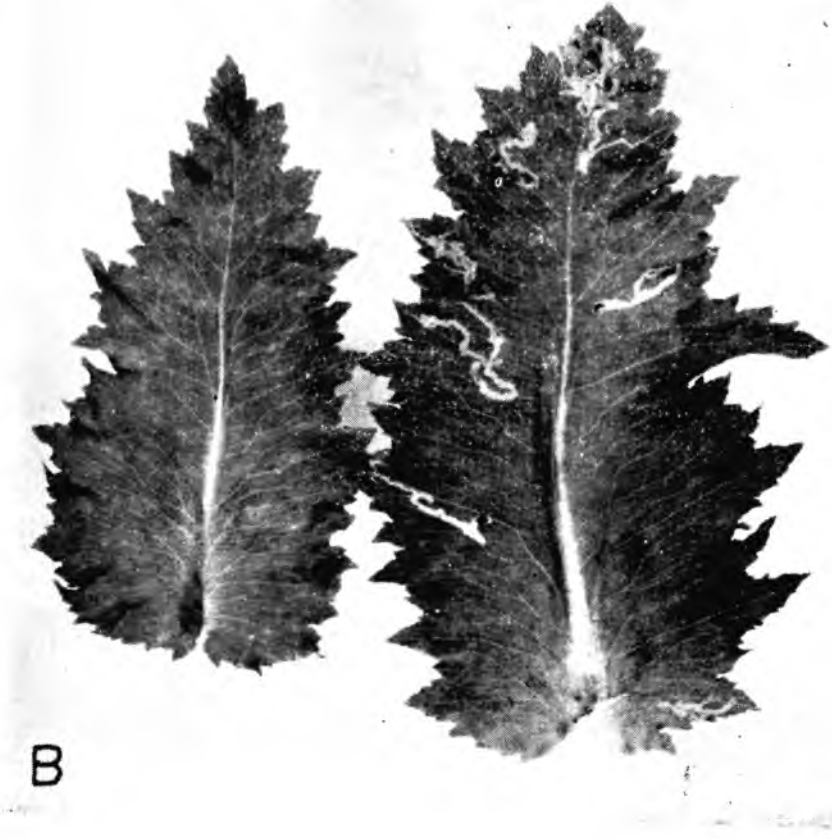
TABLE 1. Intensity of leaf miner damage on two strains of opium poppy.

Strain	Number of mines/20 leaves		
	Lower leaf	Middle leaf	Top leaf
SLS	8.00	4.80	1.05
DFLS	21.50	16.70	2.60

SLS = Smooth leaf strain.
DFLS = Deep fringed leaf strain.

The intensity of leaf mines on opium poppy was observed on March 16, 1982 in a plant breeding experimental field (Crop sown on October 30, 1981) resulted in higher number of mines on leaf lamina of a deep fringed leaf strains (21.50 mine/20 leaf) as compared to smooth leaf strains (8 00 mine/20 leaf). Lower leaves of opium poppy were more damaged as compared to middle and top leaves in each strain (Table 1). This preference of the pest for deep fringed leaf strains appeared to be due to morphological characters of the leaves (Fig. 2).





A. Damaged leaf of deep fringed leaf strain (left) and the healthy leaf of the strain (right). B. Healthy leaf (left) and damaged leaf (right) of smooth leaf strain.

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Entomon 1983, *Vol.* 8, *No.* 3, *pp.* 293 to 295

BRIEF COMMUNICATION

CHANGES IN PROTEIN PATTERN DURING THE MOULTING CYCLE AND METAMORPHOSIS OF *DIACRISIA OBLIQUA* (LEPIDOPTERA)

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Electrophoretic analysis of the haemolymph proteins of freshly moulted and pharate larval stages as well as pupa and imago of *Diacrisia obliqua* Walker revealed that pharate larvae contained more protein bands than the larvae at the commencement of the respective instars. Metamorphosis into pupa and imago involved disappearance of certain proteins from the haemolymph

(*Key words*: Haemolymph proteins, moulting and metamorphosis, *Diacrisia obliqua*)

Haemolymph proteins serve as carries of neutral lipids (CHINO *et al.*, 1969), steroid hormone (CHINO & GILBERT, 1971) and juvenile hormone (WHITMORE & GILBERT, 1972) in insects. They also serve as nutritional reserve (CHEN & LEVENBOOK, 1966) and many of them are enzymes. Quantitative changes of haemolymph proteins during the development of lepidopterous larvae have been reported by several authors (see WYATT, 1961). GILLIAM & JACKSON (1972) found that haemolymph protein pattern of worker bees changes during development and ageing. The present note reports changes in the haemolymph protein pattern of *Diacrisia obliqua* during moulting and metamorphosis.

Eggs of *D. obliqua* were incubated and hatched at 30°C. The larvae were fed on tender *Ricinus communis* leaves twice a day. Haemolymph from 25 to 30 larvae at the time of settling for each moult (pharate larva) as well as immediately after moulting was collected from the thorax and mixed with 40% sucrose solution in 1:1 ratio. Haemolymph proteins from individuals belonging to different instars, pupa and freshly emerged imago were separated on 7% polyacrylamide disc gel at 4°C using Tris-glycine (0.02M; pH 8.3) and Tris-HCl (0.03M; pH 8.9) as tank and gel buffers respectively (see SMITH, 1968). About 25 µl haemolymph sample was added to each gel and a constant current of 3mA was supplied. Bromophenol blue was used as a marker dye. The gels were stained for protein for 30 minutes with 1% amido black in 7% acetic acid. Destaining was carried out in 7% acetic acid.

A critical analysis of the electropherograms for the haemolymph proteins of the tested life stages of *D. obliqua* clearly indicates that the number of protein bands in the pharate larval stages (Fig. 1A C, E, G and I) is more than that at the commencement of the respective instar (Fig. 1B, D and F). Haemolymph of the terminal larva (Fig. 1, I) displayed 11 dark bands and no light band at all. During the transformation of the terminal larva into pupa 4 protein bands disappeared

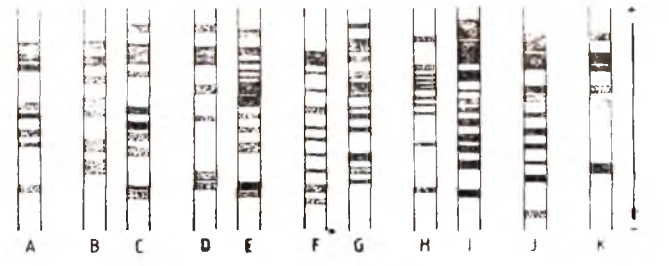

Fig. 1. Changes in haemolymph protein electrophoretic pattern during moulting and metamorphosis of *Diacrisia obliqua*. A—terminal I instar (pharate II instar); B—initial II instar; C—terminal II instar (pharate III instar); D—initial III instar; E—terminal III instar (pharate IV instar); F—initial IV instar; G—terminal IV instar (pharate V instar); H—initial V instar; I—terminal larva (pharate pupa); J—pupa; K—imago.

and 3 (light) bands were in the process of being lost from the haemolymph (Fig. 1, J). Ultimately, haemolymph of the imago contained only 3 dark bands and 3 light bands (Fig. 1, K)

The finding in the present study that the number of protein bands in the pharate larval stages was higher than that at the commencement of the respective instar is consistant with that reported by HUDSON (1966) for the tomato hornworm *Prtoparce quinquemaculata*. The increase in the number of protein bands in the course of each larval instar as well as during the entire larval life may be attributed in part to the progressive increase in the feeding rate. To tide over the non-feeding pupal and adult stages, lepidopterous larvae feed and utilise the food at a faster rate compared to other insects (PANDIAN, 1973). Change in the protein pattern during moulting also indicates the possible relation between haemolymph proteins and cuticle deposition (see FLORLIN & JEUNIAUX, 1974). Similarly, during the metamorphosis of the terminal larva into pupa and imago, proteins appear to be translocated into the fat body and ovary to enable vitellogenesis. Hydrolysis of haemolymph proteins during the non-feeding pupal period to maintain osmotic balance may also explain the decrease in the number of protein bands in the pupa and imago (WYATT, 1961).

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A TANYPODID MIDGE OF THE GENUS *CONCHAPELOPIA* FITTKAU (DIPTERA: CHIRONOMIDAE) OF INDIA

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(Received 13 November 1982)

Conchapelopia (Conchapelopia) falcistylus is described for the first time in the Orient.

(Key words:- Tanypodid midge, *Conchapelopia,* Diptera, Chironomidae)

The genus *Conchapelopia* was recognised as a subgenus of the genus *Thienemannimyia* by Fittkau (1957) with *Tanypus pallidula* Meigen as its type-species. Fittkau himself in 1962 raised the subgenus to the rank of genus which has now been proved to be acceptable to most of the workers. Roback (1971) proposed three subgenera, *Conchapelopia*, *Helopelopia* and *Macropelopia* on the basis of shape of gonostylus and lobes of gonocoxite.

The morphological terminology of the paper follows Roback (1971) and Saether (1980).

Paratypes are deposited in the National Zoological Collections, at the Zoological Survey of India, Calcutta.

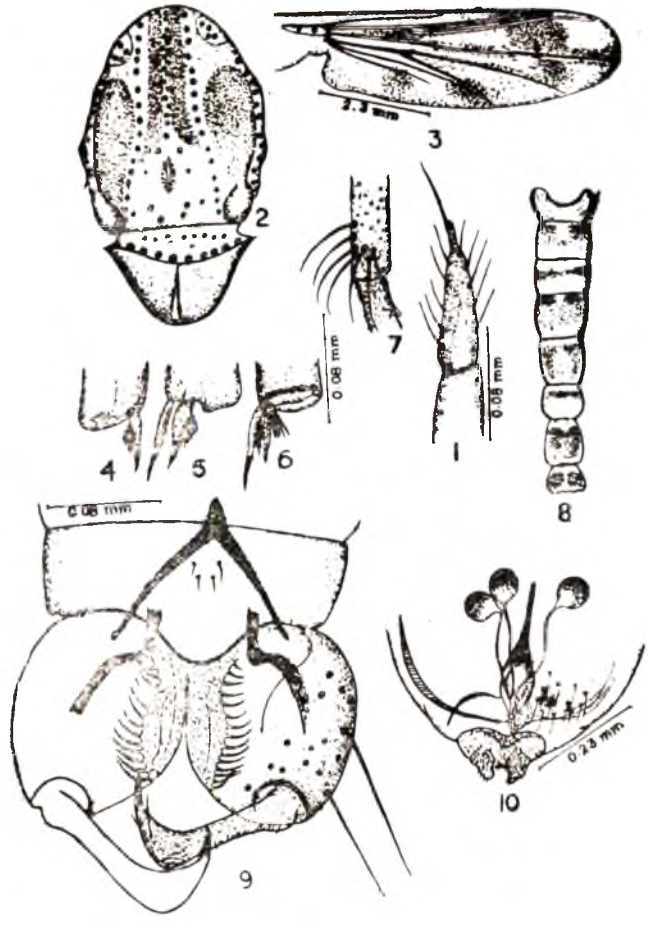
Conchapelopia (Conchapelopia) falcistylus new species

Male: Yellow in colour. Body length 3.6 (3.2-4.0, n=4) mm, wing length 1.51 (1.55-1.84, n=6) mm, wing breadth 0.66 (n=6) mm.

Head. Brown in colour. Vertex with 14 (PO 7, OV 3 and IV 4) setae; corona with 2 setae. Clypeus light brown, elongated with 17-19 long setae, clypeal ratio 3.0. Maxillary palp pale, light brown, palpomeres cylindrical, length ratio of palpomeres I-V 4: 10: 11: 12: 17, L/W ratio 5.2. Eyes naked with a dorsal extension of 0.15 mm long. Antenna light brown, flagellomere XV ending in a tubular and blunt end bearing one apical seta (Fig. 1), ratio of flagellomeres II-XV 9: 8: 7: 9: 8: 8: 8: 8: 7: 8: 8: 9: 8: 8: 172: 28, AR 2.06. CA 0.54 CP 0.21. Pedicel ratio 0.99.

Thorax (Fig. 2): Dark yellow in colour. Antepronotum with 5 antepronotals. Mesonotal tubercle well represented, longitudinal vitta yellow, median pair elongated, lateral pair broader. Acrostichals 20 in staggered row, each arm bearing 2 setae; dorsocentrals 16-17 (17) uniserial: humerals 3-4; prealars 12; prescutellars 4. Scutellum pale with 10 large posterior setae and 10-12 anterior small setae, postscutellum yellow and bare.

Wing (Fig. 3): Pale and heavily clothed with macrotrichia. Brachiolum with 2 setae and 8 sensilla; r_2+_3 scarcely discernible, costal extension very little. Wing with several distinct spots arranged as follows: 1 each at the distal half of cell R, fork of r_2+_3, cell R_4+_5, cell M, cell M and cell An; spots across fork of r_2+_3 upto cell Cu_1 coalesced. Ratio of



Explanation of the Figures 1—10. *Conchapelopia (Conchapelopia) falcistylus* new species. Figs. 1. flagellomere XV (magnified) of ♂ antenna; 2. Thorax; 3. Wing ♂; 4. Spur of fore tibia; 5. Spur of mid tibia; 6. Spur of hind tibia; 7. Apical patch of setae on tarsomere III of mid leg; 8. Abdomen; 9. ♂ hypopygium; 10. ♀ genitalia.

length from arculus to m-cu to wing tip 32: 68; ratio of length of m-cu: length from f-cu to m-cu 4:2; ratio of length of r-m: length of m-cu 5: 4. Anal lobe present. Haltere with 3 setae. Squama with 30-32 setae. VR 0.9, CR 0.89.

Leg: Pale yellowish in colour. Femora with subapical brown band, tibia slender and setaceous. Spur of fore tibia (Fig. 4) 0.03 mm long and more or less lyrate type having 6 small lateral teeth, ratio of length of spur to the apical diameter of fore tibia 9: 12; spurs of mid tibia (Fig. 5) subequal 0.03 mm and 0.04 mm long, smaller spur lyrate bearing 6 slender teeth and the larger one with 7

Proportion and ratios of leg-segments

	Fe	Ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	TR
Fore	58	61	50	25	17	12	7	0.81	—
Mid	60	61	36	15	13	12	7	0.59	—
Hind	50	70	51	26	20	13	7	0.72	1.96

very smaller teeth, ratio of length of spur to the apical diameter of mid tibia 10: 12 and 12: 12 respectively; spurs of hind tibia (Fig. 6) unequal 0.02 mm and 0.05 mm long, smaller spur curved and lyrate bearing 5 long teeth and the larger ones with 6 smaller teeth, ratio of length of spur to the apical diameter of hind tibia 7: 14 and 7: 10 respectively. Tarsomere III of mid leg with an apical patch of setae (Fig. 7). Hind tibial comb with 7 setae (0.03-0.04 mm long).

Abdomen: (Fig. 8) Tergites II-VIII with greyish basal band interrupted in the middle and with infuscations on the tergites IV-VIII. Hypopygium (Fig. 9); Tergite IX with 4 setae. Anal point broad crescent like. Gonocoxite pale, globular 0.15 mm long about 1.5 times as long as broad and beset with 4-5 apicodorsal setae, gonocoxite lobe cylindrical 0.12 mm long having a single row of 15 lateral filaments: gonostylus 0.13 mm long chopper like, curved past middle and ending in a tooth of 0.01 mm long, gonostylus 1.1 times the length of gonocoxite. Strut I curved 0.09 mm long, strut II prominent each arm of 0.01 mm long. HR 1.25, HV 2.5.

Female: Body length 2.0 (1.98-2.2, n=5) mm., wing length 1.48 (1.46-1.50, n=5) mm, wing breadth 0.62 (0.56-0.68, n=5) mm.

Similar to male with usual sex differences and other characters. Eyes as in male but bulkier and darker. Genitalia (Fig. 10); Notum 0.9 mm long. Gonapophysis VIII triangular, gonapophysis IX well developed with notum and ramus being equal; gonotergite IX relatively developed. Segment X weak. Gonocoxapodeme thick and curved. Coxosternapodeme strongly curved and thick. Labia with setae. Seminal capsule globular measuring 0.046 mm long and 0.031 mm wide. Length ratio of seminal capsule to notum 9.25. Postgenital plate well developed. Cerci 0.03 mm long with numerous setae.

Material examined: **Holotype** ♂ (type no. 120, B. U. Ent.), India, West Bengal, Raniganj, April 14, 1978, Coll· R. K. Debnath. **Allotype** ♀, data same as holotype. **Paratypes** 4 ♂♂, 2 ♀♀, Burdwan April, 19, 1979, Coll. S. K. Nandi; 3 ♂♂, 1 ♀, Raniganj, June 7, 1980, Coll. S. K. Nandi.

Remarks: This species is named as *Conchapelopia (Conchapelopia) falcistylus* because of its chopper shaped gonostylus of the male hypopygium. It is close to *C. (C.) cygnus* (Kieffer) described from Africa in colour pattern of wing and male hypopygium. In thoracic chaetotaxy, gonocoxite lobe and gonostylus of male hypopygium this species also resembles *C. (C.) pallidula* Meigen studied by Fittkau (1962). It also shows similarities in gonocoxite lobe with *C. (C.) intermedia* Fittkau (1962), *C. (C.) victor* Kieffer both described by Kieffer (1962) The new species comes nearer to *C. (C.) shrysos* (Sublette, 1964)

in wing characters and male hypopygium. The tibia spurs, abdomen and the male hypopygium of *C. (C.) gonoides* (Sublette, 1964) draws affinity with the species in question. But the following combination of characters such as, i) ending of flagellomere XV, ii) subapical band of femur, iii) pattern of spurs, iv) tarnsverse markings of the wing and v) structure of male hypopygium ensure its placement as a new member of the genus *Conchapelopia* Fittkau.

Acknowledgement: We are grateful to Professor A. D. Harrison of the University of Waterloo for kindly going through the manuscript and confirmation of the species. Sincere thanks are also due to the Head of the dept. of Zoology, University of Burdwan for laboratory facilities.

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Entomon, 1983, *Vol.* 8, *No.* 3, *pp.* 301 *to* 302

BRIEF COMMUNICATION

HIBERNATION IN *CLETUS SIGNATUS* WALK.

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(Received 28 February 1983)

Cletus signatus Walk. (Heteroptera-Coreidae) was reported by DHIMAN (1982) from India in the western districts of Uttar Pradesh. This bug is found feeding on some wild plants of the family Amaranthaceae and on cucurbitaceous vegetables, especially on bottle-gourd. No studies have yet been made on this bug and the present studies have been taken up on its hibernation.

To know the hibernation in this bug, annual population studies for two years (1979—1980) have been made at Saharanpur. Monthly average temperature has also been taken into consideration because it plays an important role in the population fluctuation of this insect. Adults of *C. signatus* hibernate under grasses, leaves and stones. During Novebber to mid February, they are found among and under the fallen leaves of mango, guava, eucalyptus and *Ficus* which form a winter cover on the ground, sought as shelter by many other insects also. A few bugs have been located hiding below the loose bricks of the wall of many houses and crumbling buildings. They also have been observed under the bark of mango and sheesem (*Dalbergia* sp.) and in the holes on the stem of these plants. They are found in the field on their host plants upto October in all stages of life cycle. However, as the cold climate sets in, they become fewer in number during the first week of November and finally disappear in mid November. During the year they were seen till November 12 and the last seen individuals were the 5th instar nymphs, the adults having already gone into hibernation and the smaller nymphs perished due to cold weather. Only larger nymphal instars survived on the host plants till their final moult could take place. The same phenomenon has been observed with *Aspongopus janus* by DHIMAN (1981). A few *C. signatus* were hibernating at a slight distance from a reduviid bug below the bark of a sheesem tree.

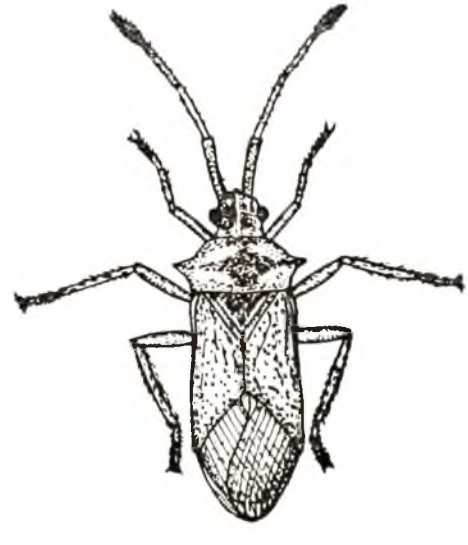

TABLE 1. Temperature and population per ten plants (PPTP) of *Cletus signatus* on *Amarantus spinosus* in 2 years.

Months	1979		1980	
	Temp.	PPTP	Temp.	PPTP
January	21.7	—	20.5	—
February	22.2	4	24.4	5
March	27.0	11	27.7	13
April	36.3	21	38.3	24
May	37.8	28	39.9	30
June	37.6	27	33.6	31
July	32.7	32	32.7	35
August	34.1	41	33.1	39
September	33.7	38	32.9	42
October	33.0	27	33.2	29
November	28.7	12	27.9	11
December	22.9	—	23.1	—

February, 15, 1979, was the earliest date of emergence after hibernation and February 21, 1980, the latest date. Adult bugs were the first individuals seen. Temperature plays an important role which compels this insect to hibernate as the colder weather resumes (Table 1.) These bugs start emerging out from their hide-outs to resume their normal life activities as the temperature starts rising. Annual population study of this insect for two consecutive years on *Amaranthus spinosus* indicates that the maximum number is found during May to October and the minimum in Februry and November (Table 1). The hibernating period in 1979 was from 18th November to 15th February, and in 1980 it was from 24th November to 21st February. The period of maximum activites of this bug extends from May to mid October in this region.

I am thankful to Dr. G. D. GARG, who is the sole source of inspiration for me and to Dr. V. C. CHATTERJEE, for helping in various ways.

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BRIEF COMMUNICATION

EUSEIUS VIGNUS A NEW SPECIES (PHYTOSEIIDAE : ACARI) FROM JAMMU AND KASHMIR

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(*Received 31 August 1982*)

A new species of predatory mite *Euseius vignus*, sp. nov. collected from wide range of economic and wild plants at different localities in Jammu and Kashmir is described. Notes on its biology are given.

(*Key words:* new species, mite, Phytoseiidae)

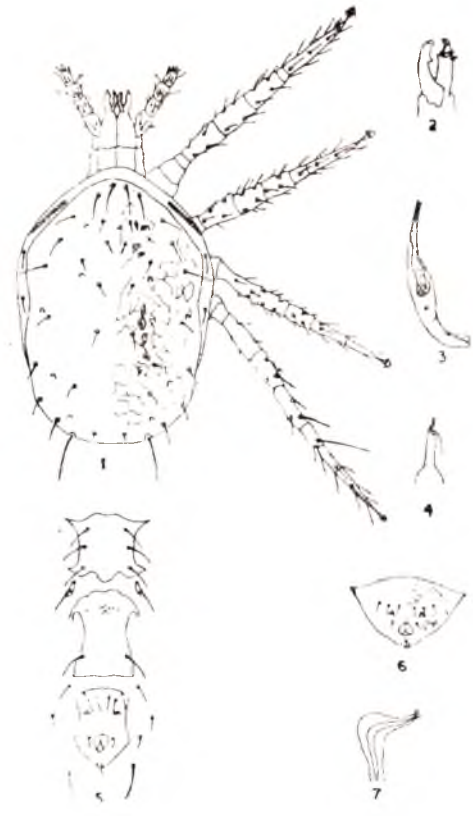
Euseius vignus sp. nov. (Figs. 1—7)

All measurements are in microns.

Female: Dorsal shield 320 long, 195 wide at L_5 with scattered lunate areas, 5 pairs of pores and 17 pairs of pointed setae. Seta L_8 longest and thickest; measurements of setae : verticals 36; $L_1$33, $L_2$25, $L_3$27, $L_4$38, L_5 — $L_6$24, $L_7$28, $L_8$74; $M_1$14, $M_2$20, $M_3$22; $D_1$14, $D_2$17, $D_3$16, $D_4$19; clunals 5; $S_1$26, $S_2$20 long. Peritreme terminates between L_1 and L_2. Sternal shield smooth, slightly longer than wide convex posteriorly with 3 pairs of setae, metasternal plate with a distinct seta. Genital shield with a pair of setae. Ventrianal shield longer than wide with a pair of preanal pores and 3 pairs of preanal setae arranged in a transverse line. Fixed digit of chelicera bidenticulate, movable digit unidenticulate. Spermatheca bears a tubular cervix, 13.5 in diameter and with nodular atrium. Leg formula 4 1 2 3. Macrosetae on leg IV as follows : Sge 23, Sti 36 and St 58. Genu II $2-\frac{2-2}{0}-1$; Genue III $1-\frac{2-2}{1}-1$.

Male: Dorsal setae being shorter than those of female. Ventrianal shield wider than long with a pair of pores and 3 pairs of preanal setae. Spermatodactyl with a terminal foot.

Holotype ♀, INDIA : JAMMU and KASHMIR: Shihama, on *Vigna aconitifolia*, 12.ix. 1980, coll. A. Q. Rather, **paratypes** 4 ♀♀ collected with the holotype: 4 ♀♀, Hazratbal, 10.x.1978 ex *Rubus niveus;* 1 ♀, 1 ♂, Chashmashahi, 5.vii.1977 ex *Trifolium pratense;* 1 ♀, Nishat, 14.vii. 1979 ex *Prunus sp.* (Apple): 2 ♀♀, Parimahal, 25.vii.1977 ex *Prunus armeniaca;* 5 ♀♀, S. P. College, 14.ix.1977 ex *Morus alba*: 2 ♀♀, Dalgate, 22.viii.1977 ex *Cucumis sativus;* 5 ♀♀, S. P. College, 21.ix. 1977 ex *Datura stramonium;* 1 ♀, Verinag 10.ix.1978 ex *Salix wallichiana;* 2 ♀♀, Tangmarg, 22.vi.1978 ex *Juglans regia;* 1 ♀, 1 ♂, Dalgate, 14.viii.1977 ex. *Cucurbita pepo;* 5 ♀♀, 2 ♂♂, Dalgate, 20.viii. 1977 ex *Phaseolus vulgaris;* 1 ♀, Nishat, 14.vii.1979 ex *Prunus domestica;* 4 ♀♀, Zabarvan, 25.ix.1978 ex *Quercus dilatata;* 2 ♀♀, Baramulla, 20.vi.1978 ex *Humulus lupulus;* 4 ♀♀, Dalgate, 20.viii.1980 ex *Vigna cylindrica;* 1 ♀, Poonch, 20.x.1979 ex *Ficus sp.;* 2 ♀♀, Dalgate, 5.viii. 1977 ex *Platanus orientalis;* 2 ♀♀, S. P. College



21.ix.1977 ex *Catalpa bignonoids;* 1 ♀, S. P. College, 21.ix.1977 ex *Lathyrus sativus;* 1 ♀, 1 ♂, S. P. College, 21.ix.1977 ex *Solanum miniatum;* 1 ♀, Chashmashahi 7.viii.1978 ex *Breea arvensis;* 5 ♀♀, Verinag, 10.ix.1978 ex *Vitis vinifera;* 1 ♀, Verinag, 10.ix.1978 ex *Strobilanthes alatus;* 4 ♀♀, University Campus, 21.x.1978 ex *Parrotiopsis jacquemontiana;* 6 ♀♀, Kishtwar, 4.x.1979 ex *Morus alba;* 2 ♀♀, Bhaderwah, 8.x.1979 ex *Tilia sp.;* 1 ♀, Dal Lake, 10.x.1978 ex *Lonicera japonica;* 2 ♀♀, S. P. College, 21.ix.1977 ex *Morus alba;* 1 ♀, Dalgate, 4.ix.1977 ex *Vitis vinifera;* 1 ♀, Dalgate, 21.viii.1977 ex *Zea mays.* 4 paratype females in Florida State Collection of Arthropods, Gainesivlle, Florida, U. S. A.

Remarks: This species resembles *Euseius scutalis* (Athias Henriot, 1957) but differs in having M_2 and M_3 about 1/2 as long as those of *Scutalis*; Sge IV 38 μm as opposed to 55 μm in *scutalis*. Macrosetae on leg IV all setaceous in *E. vignus* but slightly clavate in *scutalis*.

Biology: Euseius vignus was seen associated with *Tetranychus turkestani* (Ugarov and Nikolski), *Tetranychus urticae* (Koch) and false spider mite *Brevipalpus pulcher* (Canestrini and Fanzago) in the field. It was seen feeding mostly on the young stages of these mites. The population of predator was high at 22—29°C.

Acknowledgements: The authors are grateful to Dr. D. N. Lotedar Prof. and Head of the Zoology Department for providing facilites for the work. They are also highly indebted to Dr. H. A. Denmark, Chief of Entomology. Florida, U. S. A. for his comments on the identity of the mite and for his valuable suggestions. Finally, junior author thanks the authorities of C S I R, New Delhi for financial support.

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BRIEF COMMUNICATION

CHEMICAL CONTROL OF GRAPEVINE STEM BORER *CELOSTERNA SCABRATOR* FBR. (LAMIIDAE : COLEOPTERA) IN MAHARASHTRA

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(Received 9 August 1982)

The data of two experiments conducted at Ganeshkind Fruit Research Station, Pune (India) hava shown that injecting carbon-di-sulphide or methyl bromide @ 1 ml/hole or aluminium phosphide @ 0.75 g tablet/hole in a vine in the month of March-April is effective for the control of grapevine stem borer, *Celosterna scabrator* Fbr.

(Key words: chemical control grapewine stemborer, *Celosterna scabrator)*

Among the insect pests infesting grapevine *(Vitis vinifera* L.). the stem borer *Celosterna scabrator* Fbr.) causes serious damage to stems and branches. *Celosterna scabrator* Fbr. was recorded first time on grapevine at Ganeshkhind Fruit Research Station, Pune (Maharashtra) by UPASANI & PHADNIS in 1968. Paradichloro-benzene saturated in crude petroleum was reported to be effective against the pest (BECLON, 1931). However, little work has been otherwise done pertaining to its control and hence, present investigation was undertaken to find out the most effective chemical for the control of stem borer of grapevine.

Two field experiments were conducted at Ganeshkhind Fruit Research Station, Pune (India) during 1980 and 1981. Six treatments including control (Table 1) were replicated four times in randomized block design. In all, 48 trees (18 years old) of *Gulabi* variety were selected for experiment, two trees being selected for each treatment. Number of holes on the vine was ascertained by removing loose bark and only live holes were used for application of chemical. Chemicals except aluminium phosphide were injected with the help of syringe in live holes @ 1 ml/hole. Aluminium

TABLE 1. Efficacy of insecticides against grapevine stem borer, *Celosterna scabrator* F.

Treatment	Percentage control of the borer, 48 hrs after treatment	
	1980	1981
1. Ethylene-di-bromide @ 1 ml/hole	84.58 (69.83)	97.50 (85.39)
2. Carbion-di-sulphide @ 1 ml/hole	78.92 (62.80)	97.22 (85.13)
3. Aluminium phosphide @ 0.75 g tablet/hole	83.92 (69.60)	94.71 (80.52)
4. Petrol @ 1 ml/hole	31.66 (34.07)	49.88 (44.98)
5. Dichlorovos @ 1 ml/hole	17.55 (21.16)	28.75 (32.17)
6. Untreated (Control)	0.00 (0.00)	0.00 (0.00)
S E±	5.42	3.40
CD at 5%	15.77	10.20

Figures in parentheses are the arcsin values.

phosphide @ 0.75 g tablet/hole was introduced with the help of forceps in live holes by making small pieces. All treated and untreated holes were closed with clay. Post-count observations on opening of treated holes were recorded 48 hrs after treatment. On the basis of number of holes treated and number of holes opened, percentage control of the pest was worked out and these figures were transformed to angular values for statistical analysis.

The statistical analysis of data (Table 1) revealed that the treatment with ethylene di-bromide was most effective giving 84.58 and 97.50 per cent control of the pest in 1980 and 1981, respectively. However, it was on par with carbon di-sulphide and aluminium phosphide. The treatments with petrol and di-chlorovos were found ineffective in both the years. Hence, it is concluded that a single application with ethylene-di-bromide, carbon-di-sulphide @ 1 ml/hole and aluminium phosphide @ 0.75 g tablet/hole in live holes reduced more than 78 per cent population of grapevine stem borer within 48 hrs after treatment.

The authors are thankful to Dr. D. S. Ajri, Head, Dept. of Entomology, M. P. A. U., Rahuri, Dr. B. C. Patil, Associate Dean, College of Agriculture, Pune and Superintendent G. F. R. S., Pune for providing necessary facilities and guidance.

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BRIEF COMMUNICATION

TRIALS WITH *PARATHERESIA CLARIPALPIS* (WULP) (TACHINIDAE : DIPTERA) AN EXOTIC PARASITOID AGAINST SUGARCANE BORERS IN THE PUNJAB

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(Received 2 February 1983)

Parathersia claripalpis was colonized in three districts of Punjab against sugarcane borers, viz. *Chilo infuscatellus* and *Acigona steniella*. Recovery tests were carried out but the parasitoid was not recovered. The environmental conditions of the Punjab State are not favoutable for this parasitoid

(*Key words: Paratheresia claripalpis*, parasitoid, *Chilo infuscatellus, Acigona steniella*)

Among the sugarcane pests the internal feeders, viz. Gurdaspur borer, *Acigona steniella* (Hampson), shoot borer, *Chilo infuscatellus* (Snellen) and Tarai borer, *Chilo auricilius* (Dudgeon) (Lep: Crambidae) are very serious in the Punjab. Due to the concealed mode of the destructive stage of their life they have defied all attempts of control through methods other than biological control. Various indigenous natural enemies reported from the country (BUTANI, 1972) have failed to keep the population of these insects under check. RAO & NAGARKATTI (1971) stressed the need to introduce exotic natural enemies from the other sugarcane growing areas such as West Indies, West and East Africa and Indonesia. Keeping that in view some parasitoids were introduced including the tachinid larval parasitoid, *Paratheresia claripalpis* (Wulp). This parasitoid was introduced in the Punjab from Trinidad during August, 1976 through the Commonwealth Institute of Biological Control, Bangalore. The rearing technique reported by NAGARKATTI & RAO (1975) for rearing of a tachinid, *Sturmiopsis parasitica* (Curran) was used to mass multiply this parasitoid in the laboratory. VARMA and SINGH (1978) carried out the preliminary laboratory studies such as its biology on different hosts and host suitability. The parasitoid was colonized in the state against *A. steniella* and *C. infuscatellus* and the recovery test was also carried out. About one thousand gravid flies of *P. claripalpis* were colonized at seven different places in Jalandhar Sangrur and Kapurthala districts from April 1979 to August 1982. A total of 2945 and 1500 larvae of *A. steniella* and *C. infuscatellus* respectively were collected from the colonized area and reared on sugarcane setts in the laboratory at 26 ± 2.4°C and 69 ± 6.2 per cent relative humidity. The food was changed on alternate days.

P. claripalpis was not recovered from any of the target insect in Punjab and there are similar reports from the other areas in India also (ANONYMOUS, 1981).

It is concluded that the climatic conditions of the State are unfavourable for this parasitoid. The culture of this parasitoid was therefore terminated.

The authors are thankful to the Professor-cum-Head, Department of Entomology Punjab Agricultural University, Ludhiana for providing them with facilities for this work.

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OBITUARY

Dr. Vazirani was born in a Sindhi family in 1926 at Larkana (Sind, Pakistan). He had his earlier eduation at Karachi and got B. Sc. degree of Bombay University with Honours in Zoology and Chemistery in 1947. After the partition of the country, he migrated to India and served Zoological Survey of India, for a period of about 22 years. During his service he was awarded Ph. D. and D. Sc. degrees from the University of Bombay. In 1968—1969, he worked as French Government Scholar in the Museum Nationale d' Histoire Naturelle at Paris on aquatic beetles. For the last 4 years he was working as a Senior Taxonomist (Coleoptera) in the Commonwealth Institute of Entomology (Coleoptera) where he died in July (1983) with his boots on. May his soul rest in peace.

Dr. DHAMO K. BUTANI

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